Food Futures:
Rethinking UK Strategy

A Chatham House Report

Susan Ambler-Edwards, Kate Bailey,
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The Royal Institute of International Affairs
Chatham House
10 St James's Square
London, SW1Y 4LE
T: +44 (0) 20 7957 5700
F: +44 (0) 20 7957 5710
www.chathamhouse.org.uk

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January 2009

Executive Summary

Over the next few decades, the global food system will come under renewed pressure from the combined effects of seven fundamental factors: population growth, the nutrition transition, energy, land, water, labour and climate change. The combined effects will create constraints on food supply and if action is not taken, there is a real potential for demand growth to outstrip increases in global food production. Effects on developing countries would be devastating. Developed countries will be affected too. Expectations of abundant and ever cheaper food could come under strain. The UK can no longer afford to take its food supply for granted.

Some of the effects of change are already being felt. Global food prices are subject to increasing volatility, and are provoking defensive trade and political responses that disrupt normal market behaviour. World trade structures could come under increased pressure as continued access to scarce resources becomes a strategic concern for many countries. The UK is not immune to such activities, being dependent on a small number of critical sources and inputs from the world market – soya-based animal feed and phosphate fertilizers among them. A food crisis in the UK is not unthinkable. And, added to all these factors, the environmental impacts of modern agriculture and of the broader overall food chain can no longer be ignored.

The recent price spike has served to underline our global interdependency and demonstrated the political and social importance of affordable food. Despite today's deflationary pressures, the underlying upward pressure on EU/UK prices is likely to be maintained, particularly as the need to incorporate the true cost of resources into our food supply becomes more pressing. And as the wider impacts of food production and consumption on the nation's social and economic wellbeing become more starkly obvious, the food system will need to reflect society's choices as much as individual consumer preferences.

In this environment, 'business as usual' models could at worst fail, and at best be poor preparation for the coming period. EU/UK food supply arrangements will be required to operate profitably around a significantly higher price norm, one that reflects the true cost of resources and incorporates wider social and ecological considerations. A system that is able to reconcile the often conflicting goals of resilience, sustainability and competitiveness and that is able to meet and manage consumer expectations will become the new imperative.

"The recent price spike has served to underline our global interdependency and demonstrated the political and social importance of affordable food"

New capabilities, policy frameworks and institutions will become the cornerstones of the new system. Domestic production will continue to play a significant role in the UK food's supply. But it will need to adapt to become both productive and sustainable; technological innovation and transfer of best practice will be key. Collaborative relationships around the supply network will take on a new importance and become part of the drive for a more integrated approach. Retailers in particular will need to adapt their practices to alter the balance of risk and reward throughout the chain. But it is currently unclear whether the sectors can easily reconcile traditional commercial imperatives with the wider public interest and move from its ingrained short-termism in order to develop the more strategic focus required. For the consumer, new uncertainties over the affordability of food, along with continuing environmental and health concerns, will mean changes in consumption patterns.

Action to address the more worrying trends and their effects on the UK needs to be put in hand now. The transition will be tough; finding the right way through will become a significant determinant of national economic wellbeing. In the UK itself, national and devolved governments must recognize their role as incubators of innovation and drivers of transformation.

A detailed strategic vision of the new system, one that will avoid the worst effects of change and starts to capitalize instead on newly created opportunities, has to be the way forward. The establishment of a consortium of government, supply network interests and societal groups (media, NGOs, universities) would be a good first step to facilitate the building of this vision. The partnership would need to undertake a proactive review of current arrangements in meeting policy objectives, delivering specifically:

- a detailed picture of the new food systems needed;
- a set of indicators and metrics;
- a statement of UK's strategic and geo-political interests.

It will also be important to establish a clearer description of a sustainable diet and to develop communication and education strategies to engage the public on key food issues. Increased investment in public agriculture and food research will be needed, along with support for private-public partnership frameworks to deliver technology transfer, particularly across agriculture. The UK will continue to rely heavily on the EU for its food supplies and as a market for its food exports. Many of the mechanisms to deliver the transformation lie at this level. UK isolation is not an option and the UK will need to work closely with the EU to develop the right policy frameworks.

1. Introduction

Corporate decision-makers, government policy-makers and consumers are facing a future beset by uncertainties of resource supply and distribution. New questions are arising about the availability, accessibility and affordability of food, land, water, energy and skills – and increasingly around the adaptability of the systems needed to deliver them. 'UK Food Supply in the 21st Century: The New Dynamic' is a two-year research project that has been considering these issues. The activities supporting this project have provided a rare opportunity for stakeholders across the UK's wheat and dairy industries to examine the issues collectively. They have been supported by a research team drawn from centres of excellence around the UK and by a process that has ensured the gathering of opinion from around the supply networks concerned and from around the country, including the perspectives of stakeholders in Wales and Scotland. This is its final report.

As the UK's food supply adjusts to increasing market change, it is vital that stakeholder organizations develop a corresponding capacity to plan for these eventualities. Focusing on the supply of wheat and dairy products to the UK market, the project examined the combined effects of the global elements in play. It considered in particular the significance of individual positions taken by stakeholder sectors and organizations, and the possible economic and other breaking points of the supply networks as they are currently operated.

The project began by considering the factors involved in the global contexts, which were used to construct four global medium-term scenarios of food supply. The reactions to the scenarios of stakeholders in the wheat and dairy supply networks were then examined to develop an understanding of the implications of change both by sector and in wider systems terms. The report highlights the likely limitations of current policy frameworks and governance models in the light of the potential changes it identifies. In its conclusions and recommendations, the research team assesses the nature of food demand and supply in the future, and the options open to stakeholders across the supply network, some of which provide a basis for further study.

2. The Global Context

What we had thought of as abundant food supply is anything but. Western societies, in particular, have tended to take their food supply for granted. The global system as currently operated will reach breaking point unless action is taken.

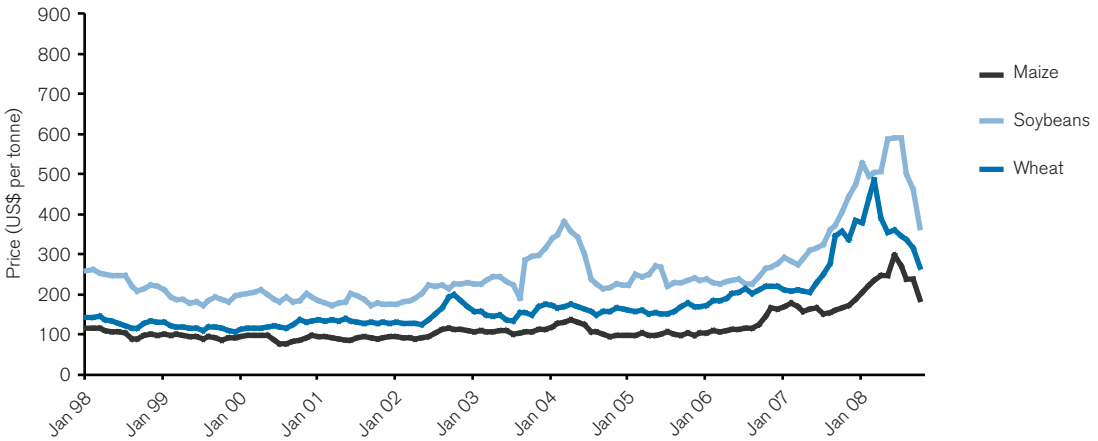
Since 2006 at least, food supply (and 'the food crisis', as it has become known) has become a serious concern for politicians, commentators and the public, particularly the poor in developed and developing countries around the world. The final year of the project's research took place against an unexpected and extraordinary increase in the world prices of many food commodities. At the time of writing, food prices have fallen from their early/mid-2008 peaks but remain at levels higher than their long-term trends. Their volatility reflects continued uncertainty about market fundamentals and their combined effects.[1]

In its report *Global Commodities* the UK Treasury charts developments from early 2006[2] when the FAO Food Price Index (FFPI) started to rise steadily, reaching a record 219 points in June 2008.[3] The upward trend in the index was fuelled by the volatile but overall hugely inflated prices of a range of key commodities including cereals, dairy products and oils and fats. As Figure 1 shows, between August 2005 and August 2008 the price of US hard wheat rose by 120%, US maize by 138% and US soybeans by 128%.

Similarly, between August 2005 and August 2008, the price of whole milk powder rose by 69% and the price of butter by 74%; the price of some meat products also increased: 10% for beef and 62% for chicken meat between June 2005 and June 2008 (Figure 2).

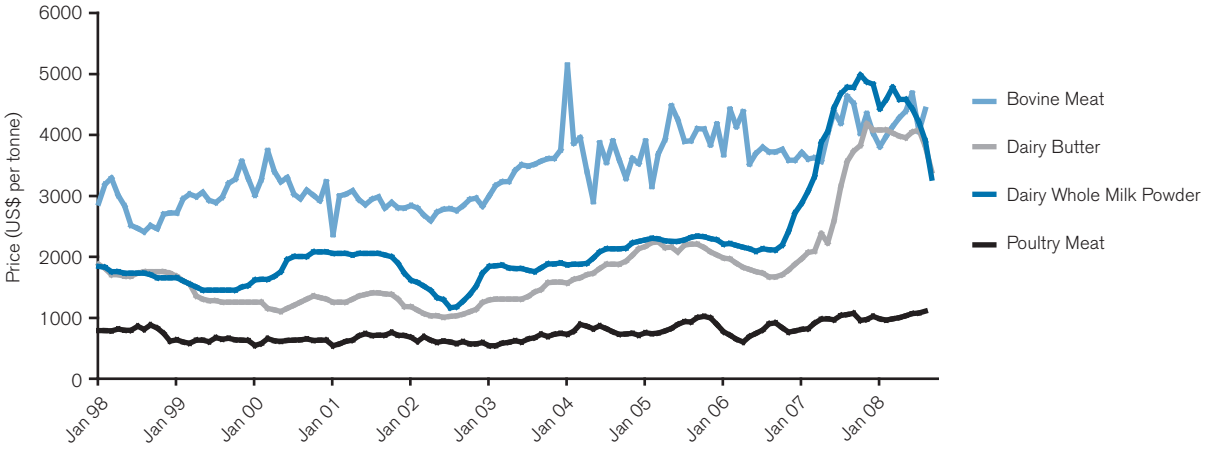
The increases in agricultural commodity prices contributed to a worldwide increase in consumer food prices. In the UK, food price inflation peaked at 12.8% in August 2008.[4] A British family that spent £100 a week on food in 2007 had to spend £634 more during 2008 to consume the same basket of goods. Other developed nations also experienced food price inflation in 2008, although it was lower than in the UK: by mid-2008, it had reached 6.7% in France, 7.4% in Germany and 7.1% in the United States.[5] For low-income countries, particularly those that import the bulk of their food, the effects of price increases have been more severe. In many cases their access

Figure 1: Price of wheat, soybeans and maize, 1998–2008



Source: FAO International Commodity Prices Database (15 September 2008), http://www.fao.org/es/esc/prices/PricesServlet.jsp?lang=en.

Figure 2: Price of dairy whole milk powder, dairy butter, bovine meat, poultry meat, 1998–2008



Source: FAO International Commodity Prices Database (15 September 2008), http://www.fao.org/es/esc/prices/PricesServlet.jsp?lang=en.

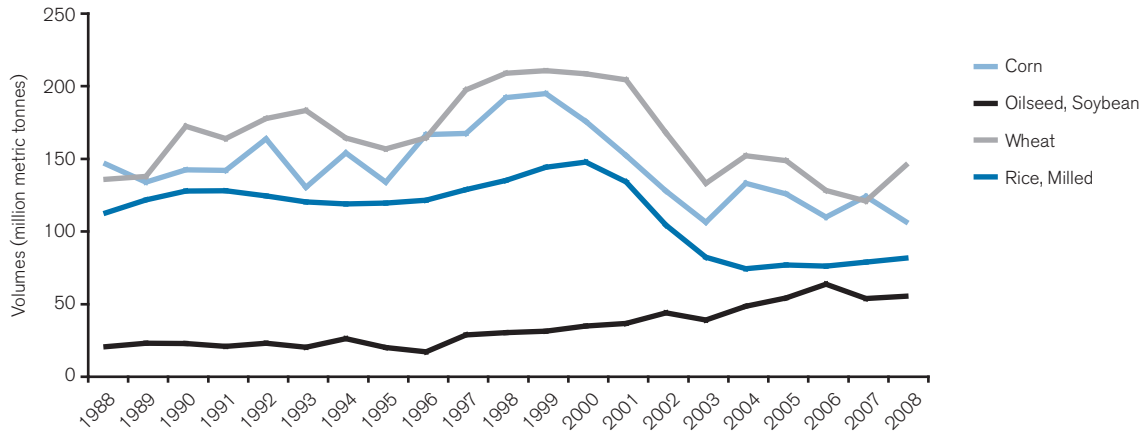
to imports has been affected by trade restrictions imposed by other countries responding to high prices. The United Nations Food and Agriculture Organization (FAO) estimates that 50 million people joined the ranks of the world's hungry in 2007;[6] that is not so surprising in circumstances where up to 70% of income (as opposed to 10% in high-income countries) is likely to be spent on food.[7] Aiding the most vulnerable also became more expensive; the cost of the UN's World Food Programme's operations increased by more than 50% between 2002 and 2007, and in 2007 world food aid flows fell to their lowest level since 1973.[8]

Food prices increased despite record harvests of staple crops over recent years. Between 2000 and 2008 the average global wheat harvest was 340 million tonnes higher than during the 1990s. Over the same period the average yearly corn harvest rose by 136 million tonnes and the soybean harvest by 76 million tonnes.[9] This anomaly can be partly explained by a number of shorter-term factors, as listed below.

- ***Low global stock levels.*** World food stocks are historically low (Figure 3). The FAO estimated that in 2007/08 the ratio of world total cereal ending-stocks to predicted world cereal usage would fall to 18.8%, the lowest in three decades.[10]

  At the close of the 2007/08 season total grain (wheat and coarse grain) stocks were estimated to be 285 million tonnes, just 5% up on the previous year after a 43% drop over 2006/07. Stocks are forecast to rise in 2008/09 by 16% (301 million tonnes) as the market responds to higher prices with greater plantings. This would still leave stock levels lower than in 2005/06 and 2004/05[11] and is unlikely to provide an effective defence against any disruptions to supply and an associated rise in prices.
- ***Weather events and disease.*** The absence of large buffer stocks exacerbated the effects on food prices of episodes of adverse weather and outbreaks of animal disease. During 2007 poor weather conditions affected a number of grain-producing countries and regions, reducing yields over large areas and contributing to lower global average yields of grains and oilseeds for the second consecutive year.[12] In 2007 prices for pig, cattle and poultry meat were also driven higher by reduced output as a result of outbreaks of disease such as porcine reproductive and respiratory syndrome virus (PRRSV) in China and es foot-and-mouth and bluetongue in the EU.
- ***The activities of speculators.*** Factors such as the weakness of the US dollar, low US interest rates and greater portfolio diversification have encouraged investors to pour billions of dollars into commodity futures, particularly 'soft' commodities such as

Figure 3: World corn, wheat, soybean and rice stocks, 1988–2008



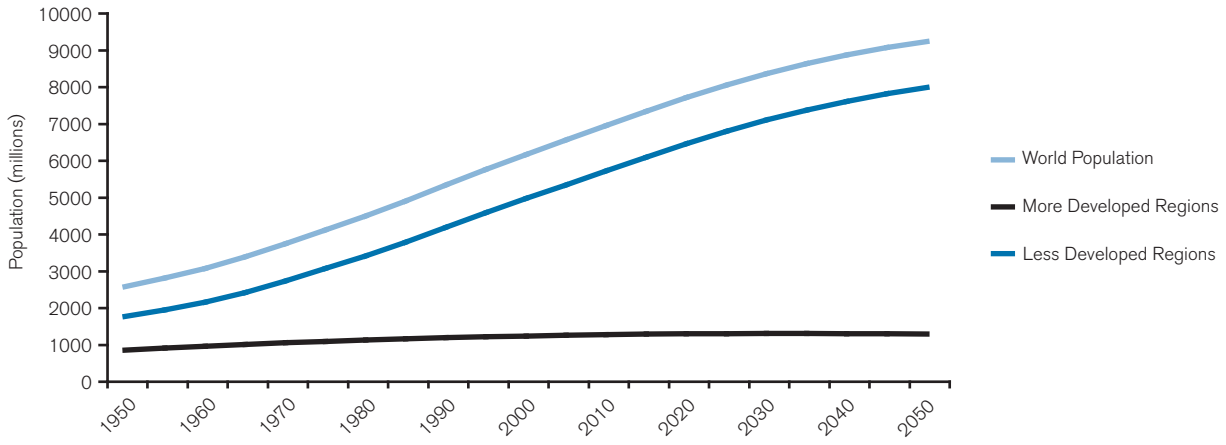
Source: USDA PSD (19 August 2008), http://www.fas.usda.gov/psdonline/psdResult.aspx.

agricultural goods. The significance of such commodities speculation for price levels remains the subject of much debate. The International Food Policy Research Institute (IFPRI) believes that it *has* added to commodity price volatility,[13] while other commentators have argued that it is unlikely to be a key cause of rising prices.[14] Speculation normally drives up commodity prices by promoting hoarding; this would normally cause the spot price to follow the futures price, but throughout 2008 there was little evidence of this.[15] Official data clearly show that stocks are falling.[16] Even commodities not included in the most popular index (Standard & Poor's Goldman Sachs Commodity Index (S&P GSCI)) – tin, coal and iron ore – saw prices rise up to mid-2008,[17] a clear indication that changes in demand and supply are still the significant determinants of movement. IFPRI argues that the crucial question in the 'speculation debate' is whether prices are any longer a reliable indicator of the underlying demand and supply fundamentals.[18] If they are not, investors, policymakers and producers will not be acting on the right signals, with potentially severe consequences for farmers and consumers around the world.

- ***The actions of governments.*** Food price inflation and the consequential bouts of social unrest seen across the world[19] have led governments, particularly in food-importing countries, to introduce a variety of measures to limit or prevent domestic price increases. Inflation-curbing behaviour has also occurred among food-exporting countries, several of which have introduced taxes or limits on exports. An extreme example of such activity is Russia's plan to form a state grain trading company to control as much as half of the country's cereal exports.[20] Restricting trade in this way will have also contributed to price inflation in the short term and may send negative signals that lead to lower supply levels and higher prices in the long term.

In addition to these shorter-term factors, many commentators argue that food prices have been affected by the development of other, longer-term ones and that this is part of the reason why, despite bumper crops, world food prices have been so high and could continue to remain above the longer-term trends (the FFPI in December 2008 was still 22% above average levels for 2006[21]). In its November 2008 *Food Outlook*, the FAO argues that the gradual return to equilibrium in food markets is not an indication that the world's food problems have been fixed.[22] The report concludes that although food prices will fall back from their peaks, driven in part by the global economic downturn acting to depress demand, they are likely to remain at higher average levels over the medium term owing to constraints

Figure 4: World population (medium variant), 1950–2050



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2005 Revision*, http://esa.un.org/unpp (accessed 22 April 2008).

on the supply response, potentially exacerbated by low levels of agricultural investment (because of low prices).[23] The downward trends in per capita (and even total) production of many commodities are a particular source of concern, affecting, as they do, not just grains but also fresh milk, sugar, rice and beef.[24] The view that longer-term factors are in play is also echoed by a number of commentators: according to Luis Cantarell, former head of Nestlé's European operations, 'there has been a fundamental shift' and the world 'will not see over the next years commodity prices return to previous levels of even two or three years ago'.[25] John Beddington, the Chief Scientific Adviser to the UK Government, has concluded that 'we are going to have to expect to have – throughout the world and not just in the UK – higher food prices'. He attributes the rise in prices principally to the increase in world population and argues that this will counter any significant reduction in prices that may result from temporary falls in commodity prices.[26]

In this volatile price environment, evidence examined by the research team suggests there are seven fundamental pressures – two associated with demand and five with supply-side factors – whose combined effects have the potential to cause a tightening of overall capacity in food markets. Left unaddressed, they threaten to lead to a significant deterioration in the balance between the global demand for food and the capacity of world agriculture to supply it.

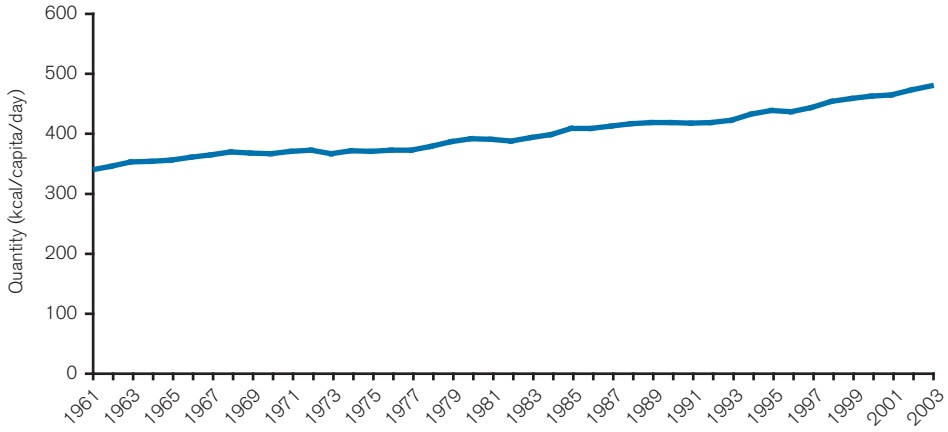
The first fundamental is a rapidly rising world population. Population expansion is a key driver of the long-term increase in food demand (Figure 4) and although the total rate of population growth is slowing down, it is estimated that the world may need to feed over nine billion people by 2050. According to projections, over 95% of this growth will occur in the developing world where, by 2050, 86% of the world's population will live.[27]

Already it seems that population growth is affecting food availability (and arguably, therefore, food prices). Annual global per capita grain production has declined, falling from its peak of 342 kg in 1984 to 302 kg in 2006, and total world grain production has fallen short of global demand in seven of the last eight years.[28]

Many developing countries continue to struggle to meet their populations' demand for basic food. Others, particularly those that have achieved high rates of economic growth and have expanding urban populations, are seeing rising incomes directed towards the purchase of a greater quantity and variety of foodstuffs.

Rapid urbanization is also changing the shape of the food system and patterns of demand. In 1961, one billion of the world's population lived in urban areas. The total had reached three billion by 2003 and is projected to be five billion by 2030. The scale of movement and the associated change in consumption are unprecedented.

Figure 5: World average consumption of animal products, 1961–2003



Source: GEO Data Portal, FAOSTAT (2004), http://faostat.fao.org.

The second fundamental is the effect of the 'nutrition transition'. The so-called nutrition transition is a feature of countries' development and the increasing affluence of their populations. It involves a shift away from traditional staples such as roots and tubers, and a corresponding increase in the consumption of meat and dairy products (Figure 5), refined and processed food, and sugars, oils and fats.

The trend is already well established, with the demand for meat in developing countries doubling between 1986 and 2007. By 2007, Chinese annual average (per capita) meat consumption had risen to 50 kg from a level of just 20 kg in 1985.[29] China alone accounts for 57% of the rise in total meat production in developing countries.[30] As the trend continues, China and other countries undergoing the nutrition transition such as India, Thailand and Egypt will require ever greater amounts of animal feed, water and grazing land and are likely to have to import some of their feed and livestock products to meet future demand.[31] This will tend to strengthen the negative environmental impact associated with the livestock sector. Rising demand as a result of the nutrition transition may best be described as a long-term underlying shift. It will continue to cause upward pressure on world food and feed crop prices and is likely to be influenced only marginally by global economic conditions.

As people consume a greater proportion of sugar, meat, dairy products, oils and fats in their diet there is a rise in diet-related chronic diseases such as heart disease, cancer and diabetes. In the UK the cost to the economy of these health problems is around £10 billion per year, with £7.7 billion of that spent on National Health Service treatment.[32] The World Health Organization argues that obesity has become a global epidemic. More than one billion adults are overweight and at least 300 million of them are clinically obese. In developing countries, the problem of obesity coexists with that of under-nutrition.[33]

Waste is another characteristic of the transition to a more affluent diet. By definition, it consumes available resources to no good effect, adding to the upward pressure on prices. In addition to on-farm spoilage and in-store wastage, considerable quantities of food are wasted by consumers. In the UK they throw away about a third of all food purchased (some 6.7 million tonnes each year in England and Wales, according to the Waste and Resources Action Programme[34]) – more than half of which is edible. In the US, where 27% of the food available for consumption is wasted, the US Department of Agriculture estimates that recovering just 5% of it could feed four million people a day.[35] Over-consumption and food waste are by no means confined to developed nations. In Chinese culture, conspicuous food consumption is a marker of economic and political success. The resulting excess creates significant

levels of waste; more than 1,000 tonnes a day is thrown out by restaurants in Shanghai alone.[36]

The third fundamental is energy. The cost of energy and the degree of energy dependency in modern food production systems are significant determinants of food prices. Although oil prices are volatile, the level has risen considerably over the last decade and other energy input prices, for electricity and gas in particular, have also increased steeply. At the same time, energy policies are creating new pressures to reduce energy consumption and increase efficiency. For all these reasons, the energy input costs for agriculture and food businesses are likely to remain high and may well continue to rise sharply in the future. If projections from the International Energy Agency and others prove correct and oil prices do rebound once the global economy recovers, corresponding effects must be anticipated on food production.

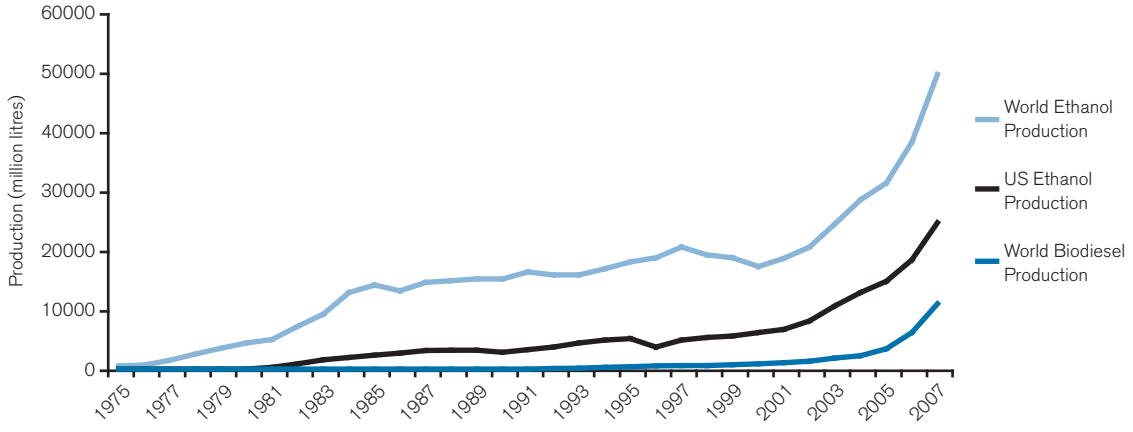
There is ample evidence of the significant effects of energy costs on industrial food production. Producing one tonne of maize in the US requires 160 litres of oil, compared with just 4.8 litres in Mexico where farmers rely on more traditional methods. In 2005, expenditure on energy accounted for as much as 16% of total US agricultural production costs, one-third for fuel, including electricity, and two-thirds indirectly for the production of fertilizer and chemicals.[37]

Similarly, the price of natural gas, which tends to follow the pattern of changes in the oil price, accounts for 75–90% of fertilizer production costs. The World Bank warned in 2008 that high fertilizer costs, directly related to high energy prices, could reduce agricultural production, especially in poorer countries, causing further shortages and inflating food prices.[38]

Food prices are also linked to energy prices through freight costs. It is estimated that 4% of US food costs are attributable to transport expenses; aviation fuel alone represents about 7% of a retail basket of high-value products in a UK supermarket.[39] The Baltic Dry Index (the global benchmark for the cost of shipping commodities) reached a record high in October 2007 and remained at significant levels throughout the first half of 2008.[40] While the global economic downturn has since led to a collapse in rates,[41] the potential for movements in freight rates to cause changes to trade patterns was noted by the FAO, which reported a 'noticeable reduction in the degree of world market integration' throughout 2007. This meant, in other words, that regional prices had fallen out of line with world prices as countries switched to sourcing commodities more locally in order to reduce transport costs.[42]

Food markets and energy markets have also become more closely linked through the increasing diversion of food commodities to the market for 'first-generation' bio-ethanol and bio-diesel-based fuel (Figure 6). Most biofuel production

Figure 6: World and US ethanol and biodiesel production, 1975–2007



Sources: 1975–2006: F.O. Licht in Worldwatch Institute (2008), *Vital Signs 2007–2008*, W.W. Norton & Company, New York, London, p. 41; USA: *EIA Annual Energy Review*, Table 10.3, http://www.wia.doe.gov; Production 2007: F.O. Licht cited in Renewable Fuels Association, *Ethanol Industry Outlook 2008: Changing the Climate*, p. 16, http://www.ethanolrfa.org.

is policy-driven, heavily subsidized by government and protected by import restrictions.[43] OECD member countries spent US$15 billion on biofuels during 2007, and many countries have set targets for their use. On UK filling-station forecourts, bio-ethanol or bio-diesel already accounts for 2.5% of fuel, and under current proposals the proportion is set to increase to 5% by 2010.[44] Proponents of biofuels cite their benefits as reduced greenhouse gas emissions and fuel costs, increased fuel security, the creation of (animal) feed-quality by-products and higher incomes for farmers. But opposition is growing. Reasons include the morality in a hungry world of converting food into fuel, the risks to bio-diversity, and doubts about the true 'green dividend' of this generation of biofuel-based products. It is clear that the performance and risk of different biofuels against these concerns vary. The International Monetary Fund (IMF) argues that while greenhouse gas emissions from Brazilian sugarcane ethanol are 91% lower per kilometre than petrol, the comparative environmental benefits of corn- and wheat-based ethanol are minimal.[45] Other studies on the net energy return of biofuels have reached varying conclusions: a USDA study reported a positive return,[46] whereas Pimentel and Patzek calculated that the fossil fuels required for the manufacture of bio-ethanol from maize used 29% more energy than was produced.[47]

The impact of biofuel production on food prices is difficult to measure. As yet, it represents a relatively small proportion of the total global supply of grains and oilseeds, the major crops affected being maize, rapeseed and sugarcane. Current estimates of its impact on food prices in 2007/08 range from as much as 70–75% to as little as 3%,[48] depending on the methodology used. Second-generation biofuels will use non-food crops and utilize a greater proportion of the plant. But a commercially viable product is not expected to emerge in the near future. The barriers to be overcome include the technological challenge of converting cellulose molecules into fermentable sugars on a large scale, and the high costs of production involved.[49]

If the effect of biofuel production on food prices is unclear, its contribution to higher levels of global grain demand is a little easier to track. Between 1990 and 2005 annual global demand increased at a relatively stable 21 million tonnes per year on average,[50] driven principally by rising demand from consumers and livestock. But between 2006 and 2007 the quantity of grain diverted to industrial uses (principally maize for bio-ethanol production) climbed from 54 million to 81 million tonnes, causing the world's annual demand for grain to increase in turn by an *extra* 27 million tonnes.[51] To meet this demand, land was diverted from other crops and existing grain stocks were depleted. Despite the recent re-examination of biofuel policy in the EU (where a reduction in subsidies, along with high vegetable oil prices, has rendered many biodiesel plants unprofitable), the IMF judgment is that, without a policy change, demand pressures from US ethanol production will continue to divert increasing quantities of grain from food and feed.[52]

"Between 2006 and 2007 the quantity of grain diverted to industrial uses climbed from 54 million to 81 million tonnes, causing the world's annual demand for grain to increase in turn by an *extra* 27 million tonnes"

The expansion of biofuel production is changing how land is used. A World Bank study has estimated that the area of US land planted with maize increased by 23% in 2007, resulting in a 16% decline in the area planted with soybeans; that in turn contributed to a 75% rise in soybean prices between April 2007 and April 2008.[53] Over the same period, the EU and other wheat-exporting countries produced oilseeds for bio-diesel on land formerly planted with wheat. Had that change not occurred, global wheat stocks in 2007 would have been almost as high as in 2001, rather than nearly 50% lower.[54]

The fourth fundamental is land. The world's agricultural land area increased gradually from 4.49 billion acres to 4.96 billion acres between 1965 and 2005 (a 10.4% increase). Only 7.2% of this increase occurred between

1995 and 2005.[55] However, the rapid rise in global population means that the area of cultivated agricultural land per capita declined worldwide from 1.45 hectares in 1960 to just 0.78 hectares in 2003.[56] In Asia, levels have fallen by as much as 40% and in Africa by over 50%.[57]

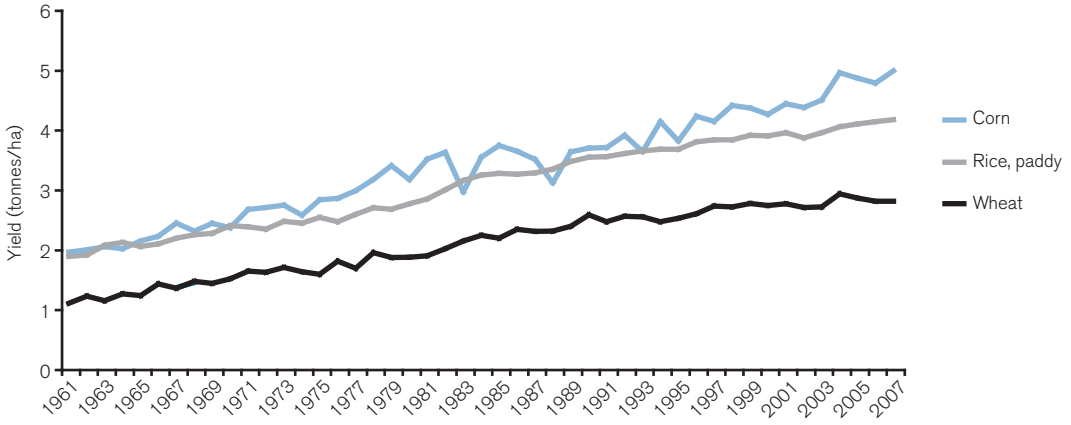
Data from the FAO Global AEZ (agro-ecological zoning) project suggest that only 22.7% of the earth's available arable land, 10.1 billion hectares,[58] is moderately to very highly suitable for rain-fed agriculture.[59] The greatest proportion of this remaining land is thought to be in Latin America and sub-Saharan Africa (the Global AEZ project believes that rain-fed cultivation potential has already been exhausted in many parts of Asia[60]). However, the bulk of the world's most productive land is already being utilized and much of the remaining land is of low quality, difficult to access as a result of poor infrastructure, more costly to work and less productive.

The extent and utility of marginal land only become issues if people are forced to farm it, which may be the case as the populations in developing countries continue to grow. On current estimates, about 12% more land globally could be brought into agricultural use;[61] a proportion of this is formerly cultivated land left fallow in recent years owing to varying factors including low agricultural prices and policy measures such as set-aside in the EU. But the assimilation of some areas would be at the expense of forest cover or areas of conservation, requiring some difficult cost/benefit judgments.

Most analysts predict that the area of cropland in use will expand only slightly in future decades. This will leave the bulk of future increases in production to be derived from greater output per hectare of land. Current measures of that output, particularly for some cereals, indicate that the growth of yield per hectare is slowing down (Figure 7). The average world wheat yield per hectare during the 1970s was 33.4% greater than in the 1960s; but in the first years of the 21st century it has been only 8.7% above that of the 1990s.[62] Corn and rice yields have followed the same trend, lending weight to the view that large gains in output per hectare are becoming more difficult to achieve. In terms of natural resources, yield per hectare relies on investment in good-quality soil, continued inputs of water, adequate supplies of skilled labour, favourable climate conditions and research and development. Current research indicates that there is cause for concern about all these factors.

Soils are being eroded or degraded in large tracts of the world's farmland (as a result of increased salinity, wind and water erosion, the over-use of chemical inputs and industrial pollution). A report from the International Assessment of Agricultural Science and Technology

Figure 7: World corn, rice and wheat yield, 1960–2007



Source: USDA PSD (19 August 2008), http://www.fas.usda.gov/psdonline/psdResult.aspx.

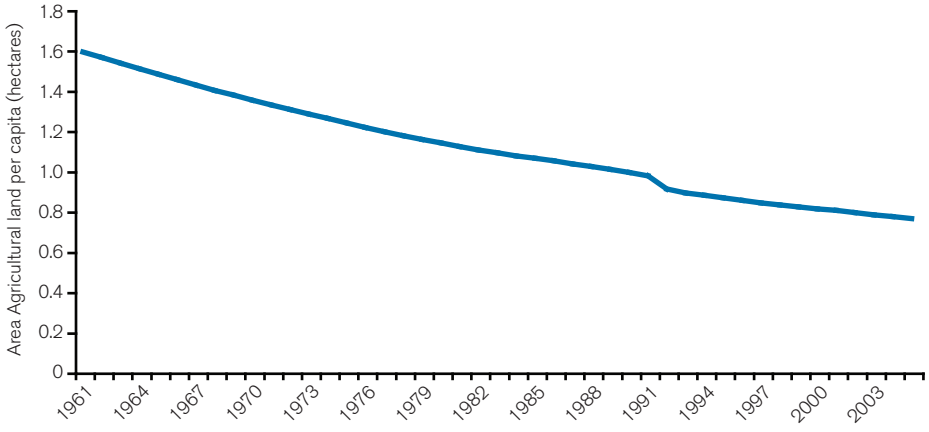
confirms this as a key factor underlying a slowing in the growth of yield levels.[63] It is estimated that past soil erosion may have depressed yields in Africa by between 2% and 40%, leading to a continent-wide fall of 8.2%.[64] Similarly in South Asia water erosion may have reduced harvests by 36 million tonnes of cereal equivalent every year, costing the region US$5.4 billion in lost income.[65] A study published in the journal *Science* found that in the 1990s soil erosion was already costing the US economy about $44bn a year.[66]

As populations increase and the land in production reaches its limits, the politics of the issue will focus increasingly on national 'footprints', each country's use of resources. A 2006 study identified levels of consumption equivalent to a notional 5.4 hectares per person in the UK.[67] In China, each person's footprint was less than a tenth of this, 0.4 hectares/person.[68] But total global agricultural land availability per person had dropped significantly by 2003 to 0.79 hectares per person (Figure 8). While trade can offer a positive means of offsetting any national imbalances in resources (i.e. lack of water), pursuing unequal shares of globally traded products (and therefore resources) by nation-states could be increasingly judged as unsustainable, both environmentally and ethically.

China and other capital-rich countries, particularly in the Middle East and North Africa, are now beginning to look outside their borders for agricultural land in an effort to ensure greater security of food supply. The head of the FAO has warned that these moves risk the creation of a 'neo-colonial' food system. Sudan, Ethiopia, Kazakhstan and Ukraine, among others, are offering hundreds of thousands of hectares of agricultural land for investment.[69] Such political moves may bring much-needed income but they will also have implications for the trade in foodstuffs and for international relations.

The fifth fundamental affecting food production is water. Producing one kilo of grain-fed beef requires 15 cubic metres of water; one kilo of cereals needs 0.4–3 cubic metres.[70] The magnitude of annual global trade in virtual water (the water embedded in food or other goods) exceeds 800 billion cubic metres a year – a flow equivalent to 10 Nile rivers.[71] This may allow the more efficient use of a precious commodity but the export of goods with high embedded water may cause environmental or social damage in countries and regions where water is already scarce. Water resource problems are often a linked result of inefficient state subsidies to agriculture or the under-pricing of irrigation water. More positively, the transfer of water across borders through the trade of commodities, particularly foodstuffs, allows countries short of water to consume foodstuffs that they could not produce themselves and to produce alternative goods which require lower inputs of water.

Figure 8: World hectares of agricultural land per capita, 1960–2005



Source: UNEP GEO Data Portal (January 2006), Original data FAOSTAT, http://geodata.grid.unep.ch and US Census Bureau, International Data Base, http://www.census.gov/ipc/www/idb (accessed 8 April 2008).

The global stresses on available water for human consumption are increasing. Overall usage stands today at 54% of the world's freshwater supply; if per capita consumption rises across the globe at the rate seen within developed countries, this could increase to 90% by 2025.[72] Even though the bulk of global agricultural production is rain-fed, it accounts for around 70% of the freshwater abstracted for human use.[73] That fact will grow in significance. The use of water for the irrigation of agricultural land has been a 'core part of the strategy to feed a doubling of the world's population'.[74] Not all this water is drawn from sustainable sources. China currently mines around 40 billion tonnes of fossil water annually from the aquifer beneath the Hai Basin. When the aquifer runs dry, the grain harvest in the basin will drop by 40 million tonnes (enough to feed 120 million people).[75] Likewise, 15% of India's food supply is produced by mining groundwater. Some 175 million Indians are fed with grain produced with water from wells that will soon go dry.[76] Many farmers around the world are depending on water that is trucked in; or they are abandoning irrigation as the cost of pumping becomes prohibitive and returning to less productive dry-land farming.[77] Rainfall and river flow are also sources of concern, as the section below explains.

The sixth fundamental, climate change, is already high on the agenda. Climate change is considered to be 'an important additional stress' on agricultural production systems already affected by high demand and degradation.[78] It is identified as a factor in disruptive weather events that have caused widespread crop losses in recent years.[79] The number of natural disasters is increasing over time, indicating that more extreme weather events are occurring.[80]

Climate change is also blamed for contributing to the more rapid spread of crop and animal disease and for changes in temperature and precipitation. The FAO warns that animal diseases are 'advancing globally' as a result of the changing climate and factors including increased transportation and urbanization, with the potential to cause more frequent supply interruptions.[81] Rising temperatures are affecting glaciers that feed some of the world's biggest rivers including the Yellow and the Ganges,[82] with potentially disastrous consequences for local irrigated crop production. Water shortages are already affecting many regions. The IPCC predicts that, by 2020, between 75 million and 250 million people are likely to be exposed to increased water stress as a result of climate change.[83] By 2050, according to UNESCO, that could increase from between two billion people in 48 countries and seven billion in 60 countries.[84]

For some regions, particularly those in temperate zones (including the UK), rising temperatures and levels of CO_2 may have some positive impacts on agriculture in the form of longer growing seasons and carbon fertilization.[85] For the world as a whole, agricultural GDP (output) is predicted to decline by 16% by 2020 as a result of climate change; agricultural output in developing countries is likely to be the most severely affected and may decline by as much as 20%.[86] Falling yields as a result of climate change will have an inflationary effect on food prices. According to one calculation, temperature increases of more than 3°C could cause prices to increase by up to 40%.[87]

The Stern report on climate change found that non-CO_2 emissions from global agriculture are responsible for 14% of global greenhouse gas (GHG) emissions. Of agriculture's emissions, 38% are attributable to fertilizers. Livestock is the second greatest source, accounting for 31%.[88] A 2006 European Union life-cycle assessment of consumer impacts found food and drink (but particularly the meat, meat products and dairy sectors) to be the most significant sources of GHGs, accounting for 20–30% of various environmental impacts of European consumption.[89]

The seventh fundamental is labour. As people move to urban areas and consume a greater and more varied diet they also become reliant on the correspondingly reduced rural population to produce their food and other agricultural commodities. In both developed and developing countries, the pressure on the agricultural workforce is increasing. The FAO records that although the agricultural workforce as a whole is shrinking (as small farmers leave the land), the number of waged agricultural workers is rising in most regions as new jobs are created, usually in export-orientated agriculture. Of the 1.1 billion agricultural workers worldwide, 40% earn a wage and do not own

agricultural land or machinery. In unstable and temporary employment, they often earn wages well below those of industrial workers, and millions live below the poverty line, with poor working conditions and little or no social or regulatory protection. The FAO warns that despite the potential of this human capital, 'agriculture cannot be sustainable' while such circumstances continue. In many countries the agricultural workforce is being decimated by AIDS. The FAO estimates that in the 25 African nations worst affected, 7 million agricultural workers have died of AIDS since 1985. The countries most affected could lose up to 25% of their agricultural labour force in less than two decades, with potentially catastrophic implications for food production.[90]

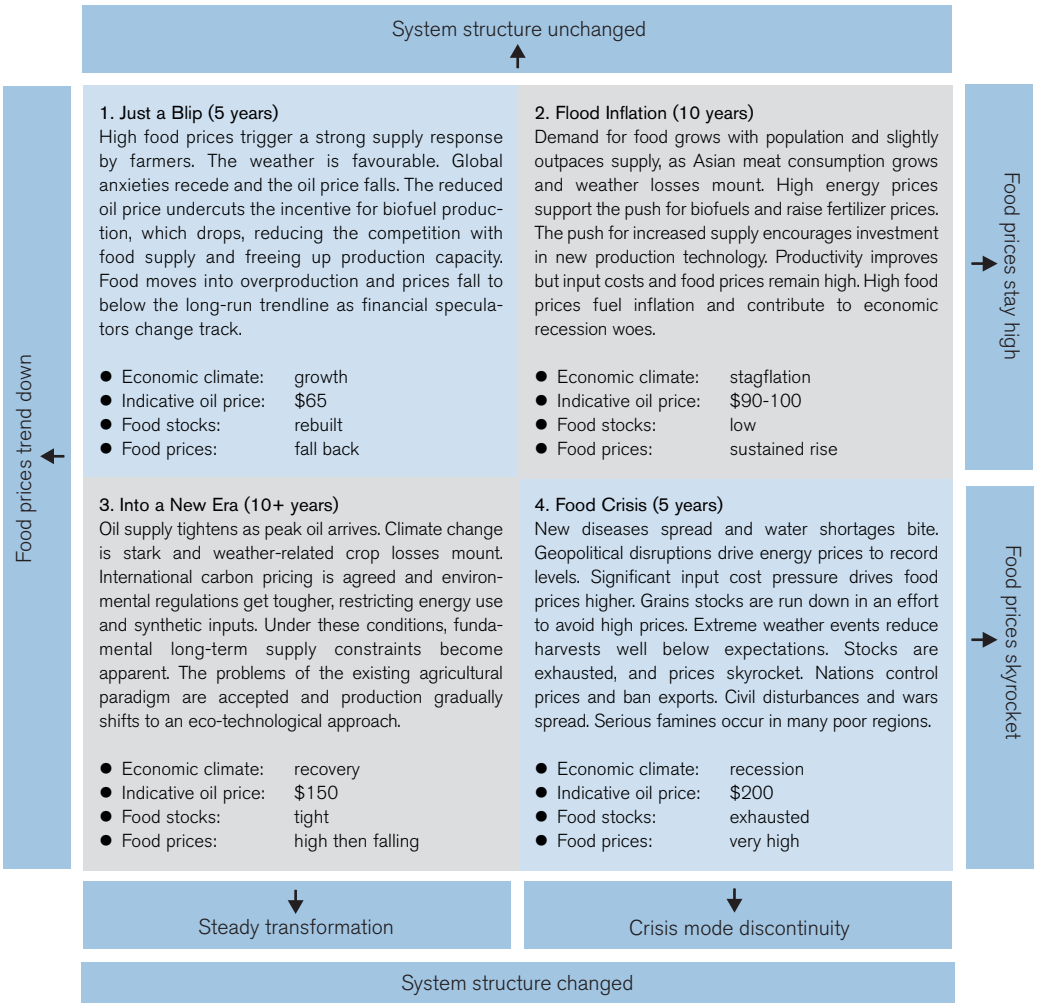
In many developed nations, migrant labour is relied upon to harvest seasonal crops such as fruit and vegetables. In the UK, US and elsewhere, the tensions between the demand from agriculture for a low-wage labour force and the tightening of overall immigration policy continue to prompt debate.

3. The Implications for the UK/EU

These new pressures will affect developed countries too. Plentiful, varied and ever cheaper food has been the norm for most people in the UK for 60 years, but the future food supply system will need to reflect society's choices as much as individual consumer preference.

A central component of the project's methodology has been the employment of scenarios to explore the implications for UK/EU food systems of a range of global circumstances. Developed from the baseline of the 'seven fundamentals' set out in Chapter 2, and by means explained in full at Annex A, four scenarios were used in a series of workshops to generate debate and subsequently test UK/EU food systems' responses to possible changes. Intended to be illustrative as opposed to predictive, the scenarios were drawn from observable trends in global food demand and supply rather than econometric models.[91]

Figure 9: Outlines of the four scenarios



The workshop discussions around the scenarios were structured to consider the effects of interactions at various points throughout the supply networks, exploring:

- why the same issues may be judged differently from different points in the network;
- the significance of the individual positions taken by stakeholders;
- possible economic and other breaking points;
- possible responses to change and the effects they generate;
- the limitations of current models of governance (regulation by public authorities, self-regulation by companies and consumer self-protection).

Outcomes relating to the UK wheat and dairy industries are summarized in Box 1. But workshop contributors then extrapolated from discussions the implications for UK food supply systems in general. These were further developed by the project team in subsequent research and analysis.

Box 1: The four scenarios

Scenario 1: 'Just a Blip'

High food prices prove to be a temporary blip and soon return to the long-term trend-line. There is a possibility, however, that if food prices fall back sharply, financial speculation in commodities will operate in reverse and lead to exaggerated food price volatility.
Workshop participants considered this to be too complacent. Though recognizing that prices may fall back in the shorter term (albeit to a higher level than before), they concluded that something more akin to structural change is occurring.[a]

Wheat

- If prices fall back, there will be little incentive for agricultural investment, particularly in R&D or plant breeding, and there will be limited effects on overall productivity.
- For industry, a blip will generate more risk-adverse strategies, with actors hedging against further blips. Post-blip, strategies will be directed towards maintaining margins. The further migration of food processing to lower-cost sources of labour will continue to feature.
- There will be minimum impact on the consumer.
- Government policy will continue to focus on environmental and health concerns.

Dairy

- The main problems will be found on the other side of the blip. It is possible that farmers' differing responses will give the sector enough robustness to weather a drop in price. But price falls could equally cause a sharp increase in exits from the industry; though herd sizes could increase to help compensate for this, the result could be a significant decline in UK milk production.
- (Wales) Wales as a country has limited scope for alternative enterprises, especially where smaller farms are concerned. That lack of alternatives could slow any decline in production as a response to market changes.

Scenario 2: 'Food Inflation'

Food prices stay high for a protracted period. They contribute significantly to inflation, but the economy adapts and the existing food system copes. The scenario is plausible; indeed, contributors commented that elements of the scenario are already observable. But to be realized in full, it would require contributing factors to be in a critical balance.

Wheat

- Higher input costs, especially fertilizer and fuel, could drive some changes in agricultural practice. While this would have a small beneficial knock-on effect on the environment, the need to maintain margins will reinforce intensive production methods.
- (Scotland) While the market for wheat is robust (as 60% is used for whisky), the cost burden will be higher owing to longer transport distances. Increase in plantings in response to higher prices will be limited owing to constraints on suitable land.
- Multinationals will potentially wield even more power within the food system. They have the flexibility to switch sourcing and methods of production/processing to suit the market.
- Longer-term supply network relationships will gain in importance as processors and retailers try to lock in prices and protect supply sources.
- Higher prices may create the impetus for the removal of single farm payments.

Dairy

- Rising input prices will increase the costs associated with keeping herds. To counteract this, producers will look to more industrialized, intensive methods of production.
- Pressures to source dairy commodity products from the cheapest suppliers will intensify (those with a comparative advantage found, for example, in Eastern Europe). This will increase competition from EU accession countries and may lead to higher levels of UK imports.
- Waste will become more of a concern and all sectors will look to eliminate waste, if only as a mechanism to cut costs.
- As sustained price rises start to have a noticeable effect, there will be greater acceptance among poorer consumers of intensive production methods and less priority given to animal welfare, environmental or ethical considerations.
- (Wales) Increased input costs will not have as much impact owing to the prevalence of grass-based systems, creating opportunities for increased production. However, transport distances and land prices may act as barriers to expansion.

Scenario 3: 'Into a New Era'

Input prices initially stay high as per capita production falls steadily. In response, the system of food production is required to shift dramatically so that increased yields are delivered efficiently through 'regenerative' rather than purely 'extractive' uses of resources. Current debate recognizes that high commodity prices may be due in part to the possibility of long-run capacity constraints in resources across the board. Whether sufficiently high yields can be achieved through an alternative production paradigm is certainly controversial, particularly as the whole concept runs counter to the existing approach of industrialized agriculture. But many observers maintain that a new approach is feasible and that numerous pockets of innovation are already pushing in this direction.

Wheat

- Significant investment in a diverse portfolio of technologies will be required including crop breeding of UK-specific varieties (genetically modified and conventional).
- More land in the UK will come under cultivation and the demand for agricultural labour will grow. This may reverse rural depopulation to some degree.
- Any moves towards more regionally or locally based solutions pose difficulties for multinational companies. This may create advantages for those organizations that already operate on a more regional basis.
- Consumers may make purchasing decisions based more on the true value of food. This could lead to lower consumption overall and particularly of meat, livestock products and even wheat.
- The need to encourage change in agricultural practice may increase calls to reinstate subsidies based on production.

Dairy

- Significant levels of technological innovation will be needed to support a new production paradigm, particularly in methods to control methane if the sector is to meet environmental standards.
- Innovation in product, process and packaging development will be needed to meet these new standards. There may be some conflict between the application of science and any perceived decline in the 'naturalness' of products.
- While there are big opportunities for innovation in the dairy sector, it is unclear whether the industry alone would be able to generate the required funds. In particular, any reduction in the consumption of milk products would create additional barriers to investment.
- Demand from consumers for stricter environmental, ethical and welfare regulation will be linked to demands for greater transparency of products' standards and provenance.
- There may be lower levels of consumption overall; this has the potential for 'nutrition transition in reverse', with reduced consumption of meat and livestock products.
- (Wales) Given the degree of coherence between its environmental policy and measures to support the farm base, Wales is better placed than England to meet the challenges in this scenario.

Scenario 4: 'Food in Crisis'

Multiple shocks disrupt food production and supply. Prices skyrocket as stocks plummet, triggering food shortages, famine and civil panic. Against a background of low global food stocks, the 2008 food price peaks are a reminder of how quickly localized, serious shortages can develop.

Wheat

- Pig, poultry and egg producers rely on grain for feed. They could go out of business if grain supplies are diverted to human food production or if prices rise prohibitively.
- (Scotland) Scotland already has a high proportion of grass-fed livestock so rising feed costs will have a less of an impact, or adaptation will be easier.
- Restrictions on trade and consumer preferences for local food could see retailers switching to UK sources and thus driving more locally/regionally based supply solutions.
- (Scotland) Scotch whisky, and therefore the Scottish economy, will suffer if increased volumes of cereal are directed towards food manufacture.
- The EU will have the option of lifting restrictions such as those associated with farm-based environmental regulation, product testing and the fast-track approval of novel foods (e.g. GM foodstuffs).

Dairy

- Herd replacement will become a key factor determining the success of individual farming units. This will be dependent on the availability of replacements and access to capital.
- There will be some switching from dairy products to crops, which will place additional pressure on resources such as fertilizer.
- (Wales) Welsh agriculture has a particular vulnerability in its over-reliance on livestock.
- (Wales) Acute rises in oil prices and transport costs would be a severe disadvantage to Welsh producers and processors who are located at a distance from their main markets.
- Product ranges will rapidly be rationalized with a focus on basic foods (less processing). Substitute dairy products may gain in importance.
- UK production will switch predominantly to liquid milk, resulting in over-capacity in the processing sector. Stocks of dairy products (UHT milk, cheese) will be run down.
- Securing supplies of raw materials will become a key priority. This could trigger more partnership-based approaches across the supply network, with retailers more likely to invest directly in farm-based operations.
- Supply chains will shorten and simplify, prompting a focus on local production wherever viable.
- Enforcement of food standards will become even more crucial, particularly to combat any rise in 'fake foods'.
- In circumstances of severe crisis, judgments as to the national interest may mean that some elements of EU policy are temporarily set aside.

a Global economic circumstances would suggest that the scenario of 'Just a Blip' is already occurring, even though participants at the time thought this an unlikely event. However, many still see this as temporary relief, with increased volatility in commodity markets, concerns over resource scarcity and increasing price pressures on energy all still creating the potential to move into the other scenarios over the medium term.

Prices and prospects

Global circumstances and the resulting pressures on supply are likely to combine to create higher food prices for the EU/UK. The recent softening of prices (wheat futures had fallen from the high of £180 per tonne in 2007 to just around £90 per tonne in December 2008[92]) is viewed by workshop contributors as a 'fragile peace', one that could be broken at any time by the effects of underlying imbalances in global supply and demand. While the oil price had fallen below $50 a barrel as of December 2008, tight market conditions are expected to return in line with eventual global economic recovery.[93] Higher oil prices and higher input costs for fertilizers and animal feed are likely to continue to be important drivers of food prices in the coming decade. The relative level of sterling will remain a key factor, and its recent weakening has contributed to inflationary pressures on inputs. A further expansion of the EU's environmental regulation regime, along with the introduction of carbon pricing, could also exacerbate the position in the short to medium term. The pain will increase if adjustments continue to have to be made in the context of a sustained global economic downturn.

For the British consumer, this spells the end of the era of cheap food and an increasingly challenging market-place for business. Higher food prices along with increasing energy and fuel costs will create further pressures on disposable income and create a potentially difficult operating environment. As price becomes ever more strongly the overriding purchasing factor, there could be stagnation in areas of the market focused on premium/niche foods, and values-based products (organic, fair trade and higher welfare ranges).

The future could also see increased social division, with those on lower incomes hardest hit by price rises. Industry's response to market changes – product reformulations and a marked bifurcation between commodity and premium foods – could make access to healthier diets more difficult for lower-income groups. Managing inflation will present major challenges to the food supply network. It will be hard to strike the balance required between consumer expectations, the need to increase market share, and belief in the ability of a competitive food system to deliver year-on-year cost reductions. Particular tensions are likely to emerge over consumer acceptance of tax burdens created by health or environmental policy priorities. At the same time, and paradoxically, it is higher prices that could fuel the investment required to develop more sustainable patterns of behaviour. In this regard, reducing waste and encouraging lower levels of consumption, including of the more resource-intensive foods such as meat, will become issues of increasing importance.

Supply network professionals regard a major food crisis in the UK as highly likely. A global crisis, as described in Scenario 4, could spill over into the UK. A crisis could develop through some form of external 'shock' such as animal or crop disease, or extreme weather events. A global food crisis caused by harvest failure and food shortages could also impact directly on British interests through restrictions in trade and reduced availability of both agricultural commodities and key inputs to domestic food production. But one feature of the new market circumstances is that the state of 'crisis' can occur without a specific disruptive event. Workshop participants took the view that the more extreme effects normally associated with 'crisis' are likely to be experienced simply by remaining in a sustained period of inflation (in circumstances described in the *Food Inflation* scenario).

Within the sectors examined in the course of this research, reliance on global trade is increasingly identified as a strategic issue. Although the UK sources 55% of its imports from the EU,[94] the total masks a high level of reliance on non-EU sources for fruit, animal feed (soya), and fertilizers (some 32% of which are sourced from non-EU countries).[95] While the FAO-OECD projects growth in global trade, these predictions are made under certain contained assumptions around energy prices, and any steep rises could cause some contraction. In addition, the predicted growth may not be sufficient to offset the very strong competition for commodities fuelled by rising global demand (signalled by the projection of continued below-average stock-to-use ratios for cereals in particular).[96] Rising demand for agricultural products will add to pressures on key resources such as water, oil and minerals. Supplies of phosphate are becoming scarcer, making those countries with concentrated

resources increasingly important for global agriculture.[97] Price volatility and the growing impact of climate change on harvests will also increase uncertainties.

The need for a more sustainable system

Environmental sustainability is seen as a major concern that will affect the capacity of UK business and agriculture to remain competitive and increase market share. Adaptation to changes in climate and the need to reduce damaging greenhouse gas emissions are considered key priorities.

> "One crucial question for the future of the food system will be how manage the transition to a sustainable system that can also deliver the desired volume of food"

One crucial question for the future of the food system will be how to manage the transition to a sustainable system that can also deliver the desired volume of food. Although current methods of industrialized agriculture are widely recognized as ultimately unsustainable, there is huge debate about the ways in which agriculture should be required to adapt. The term 'agro-ecological approaches', as originally conceived within the scenario *Into a New Era* (it was later changed to 'eco-technological approaches'), was intended to embrace a wide range of systems. However, within the industry the term 'agro-ecological' was seen to be synonymous with organic systems and engendered little confidence that there was any convincing prospect of these types of systems delivering the yields required. Rightly or wrongly, they are perceived as producing significantly lower yields than current systems while being more land- and labour-intensive. If organic production is taken as a basis for comparison, available data in the UK suggest wheat yields of around 4.5–5 tonnes/ha,[98] compared with an average UK yield for wheat of 7.2 tonnes/ha;[99] this difference is predominantly due to the leverage delivered by the application of inorganic fertilizer. Organic dairy systems are also likely to produce 33% less output than their conventional counterparts.[100] However, non-organic fertilizer application is problematic in terms of both pollution and emissions. It has become established practice over the last 50 years and has only recently seen a decline in usage (nitrogen application rates have dropped by 22% from 1983 levels[101]). Higher fertilizer prices and increasing regulation, such as the introduction of nitrate control zones, may be greater incentives for farmers to switch to lower usage rates. But a combination of ingrained practice and concerns over any detrimental effect on yields would make it very tough to deliver any radical change of approach. Moreover, stakeholders believe that environmental regulation threatens to ignore the requirements and priorities of the food system. Many in the UK wheat industry, for instance, fear that further restrictions proposed on pesticide use would severely reduce cereal and horticultural crop yields across the EU.[102] In the dairy industry, there is concern that the introduction of nitrate control zones, particularly across England, could also lead to restricted output.

UK system capacity

There is widespread concern over the erosion of capacity within the UK farming sector and its reduced ability to compete in the global arena. While land prices have risen, values of other fixed assets such as buildings and machinery have declined by 14% since 1990.[103] Productivity has tailed off since 2002 and in comparison with other nations the UK agricultural sector shows very poor growth and levels of efficiency.[104] Economies of scale play a large part, as does the failure to exploit supporting technologies.

Investment in farm expansion, innovation and skills is central to maintaining competitiveness. Notwithstanding higher prices and higher levels of income, investors are discouraged by the curtailing of margins in the wheat and dairy sectors through rising input costs. The high price of land is also an important factor. UK fiscal policy (in

particular capital gains tax and agricultural property relief) encourages land ownership as a speculative investment. The owner-occupier model of farming is favoured while tenant farmers and potential new entrants to farming are disadvantaged, although contract farming has increasingly proved to be a significant route in. The rise in contract farming, which is also linked to the adoption of new sustainability-led ideas and methods, is significant given the reported high average age of UK farmers (58, although this statistic may be misleading owing to the way farm ownership is reported).[105]

There are also uncertainties over the longer-term capacity of some sectors of the UK agricultural base. While the wheat sector is considered robust, the dairy sector is more vulnerable. A significant contraction could follow either a shock-based disruption such as animal disease, or sustained economic uncertainties fuelled by continued high input costs and increased global competition. In addition, stakeholders express concern that further environmental measures to manage pollution (such as an increase in the number of nitrate control zones) or the extension of proposed carbon trading schemes to include the dairy sector, would have a disproportionate effect on this sector.

The food processing and manufacturing sector has also seen capital expenditure fall by 21% since 1998.[106] The influx of capital is vital to keep facilities efficient and competitive, and indeed investment will need to increase over the coming years to help support any transition to lower-carbon and more resource-efficient systems and maintain competitiveness. But any future market contraction would reduce asset utilization and returns even more, serving to further disincentivize investment. Investment is also being stalled by uncertainties surrounding future EU and national carbon trading schemes and other environmental measures.

The viability of the food system will rely on the fair operation of supply chains and a properly functioning competitive framework. Future pressures on costs are likely to drive greater consolidation in the industry, which could heighten concerns over whether farmers are receiving a fair share of value. The significant power advantage of the UK retailers and concerns over the unequal balance of risk and reward through the chain are seen as continued barriers to the fostering of more collaborative behaviour. Stakeholders also feel that the competition law framework put in place to help ensure fairer markets is now in reality acting as an additional barrier. Specific problems arise from the prohibitions relating to horizontal agreements[107] that are designed to prevent collusion and anti-competitive behaviour but that are preventing disclosure and open discussions between organizations. Rightly or wrongly, further restraints on exclusive vertically based agreements[108] are also perceived to inhibit more collaborative practices.

The acceptance, or not, of imported GM crops will be a significant issue. Genetically modified varieties of maize, soya and cotton crops are becoming widespread in major growing regions of the world. The UK/EU relies heavily on imports of non-GM soya from Brazil but the planting of conventional soya crops is rapidly diminishing across South America. This is a contributory factor to the significant increase in non-GM feed prices (soya meal from Argentina has increased by 62% since 2004[109]). Feed companies are finding it increasingly difficult to source non-GM soya and, because of problems with traceability and the potential for cross-contamination, to guarantee that products are indeed 100% non-GM. This is now an acute issue for the dairy and livestock sectors in the UK as feed prices continue to rise out of step with retail prices. GM is not yet accepted technology in the EU. At the time of writing, the EU has licensed only one GM crop variety for cultivation across Europe and imports to the bloc are subject to strict controls and approval procedures.[110] This approach, asynchronous with those of other major trading blocs, is unlikely to be sustainable in the longer term as plantings of GM increase.

Government response

Food supply will become an increasingly important political issue. There is widespread concern that governments do not fully comprehend the challenges to be faced. The government's belief that UK food security is indivisible from the global situation is seen as addressing

only one part of the issue, potentially ignoring or downplaying:

- the pressures of continuing price rises and the stresses they will place on consumer expectations of choice and unlimited availability;
- increased threats to supply resilience, including those caused by global reactions to high inflation;
- the capacity of the UK food system to respond to the challenges;
- the increasing global competition for resources;
- other countries' willingness to address the issue of global food security.

These factors could create a difficult balancing act for UK governments in their pursuit of current environmental and health priorities, particularly if fiscal measures and increased regulation create additional cost burdens. Both devolved and national governments could be faced with growing social divisions as a result of higher food (and energy) prices and will need to consider how best to minimize the impact on the poorer sectors of society. The pace of change could become a key factor here, and workshop participants argued strongly for a significant role for government in shaping change, particularly in the area of consumer response.

Differences in approaches between UK national and devolved governments towards agricultural support may come increasingly to the fore and could have serious implications whenever a coordinated response is called for. The Welsh and Scottish governments place greater emphasis on the development and support of the food system to deliver selected policy objectives, particularly on the food system as a provider of employment and a means of sustaining rural communities. The devolved governments are actively looking to provide support for agri-food chains in terms of innovation, greater integration and collaboration.

Better crisis management is considered essential, with national government playing a significant leadership role. While the nature and extent of any crisis will shape reactions, the management of the situation is more likely to fall to industry first, with initial responses tending to focus on protecting the viability of critical businesses. Any government intervention could in itself exacerbate the situation. To ensure that interventions are effective, there is a need for more partnership-based approaches, both within supply chains and with government, in order to plan and coordinate – and practise – the appropriate response to crisis.

The UK's relationship with the EU will take on even more significance. The EU is likely to provide the bulk of UK food imports for the foreseeable future. Any reduction in UK capacity or difficulties in global supply (e.g. oil-price-led transport costs) will place even greater emphasis on regional (i.e. EU) sourcing.

4. The UK's Food Supply: Responding to Change

The transition will be tough; finding the right way through will become a significant determinant of national economic wellbeing. The UK's relationship with the EU will be key.

The new normality

The UK must respond to change by constructing food supply arrangements that will avoid the worst effects illustrated in the project's scenarios. The project's research has identified four characteristics as being of increasing significance in a future food supply system (see Figure 10):

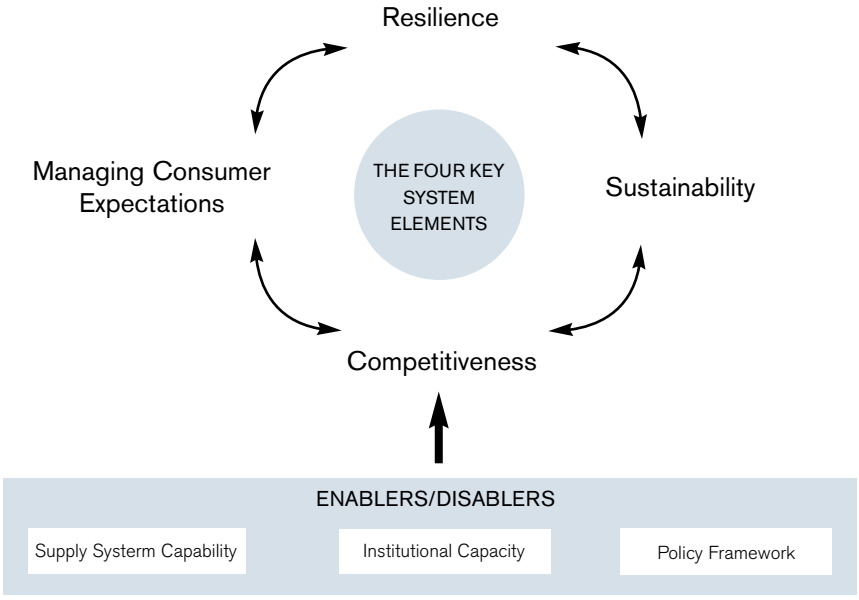
- *resilience* – a system able to assure longer-term availability in the light of increasing global uncertainties;
- *sustainability* – a system that can supply safe, healthy food with positive social benefits and low environmental impacts;
- *competitiveness* – a system capable of delivering affordable food around a potentially higher baseline of costs;
- *managing consumer expectations* – a system which shapes and responds to consumer preferences in line with societal needs.

The reconciliation of these elements will create the central challenge of the next decade. This will require a different approach with the development of a new framework of policies, institutions and supply system capabilities.

Sustainability

Upward trends in global population and affluence are intensifying pressures on natural resources even as technological innovation is hampered by poorly directed or

Figure 10: The new supply framework



Box 2: The UK's current food supply system

The last 30 years have seen a significant concentration of the UK's food retail business, with four major organizations controlling around 75% of sales.[a] Power within the system rests with these large multiples; and it is their commitment to providing the consumer with choice, 24/7 availability and low prices that drives the supply chain. A major facilitator of the current arrangements has been the evolution of a highly efficient, regionally based distribution network equipped to deal with the huge volume and range of food demanded (just under 5 billion cases of food and drink products are moved annually[b]).

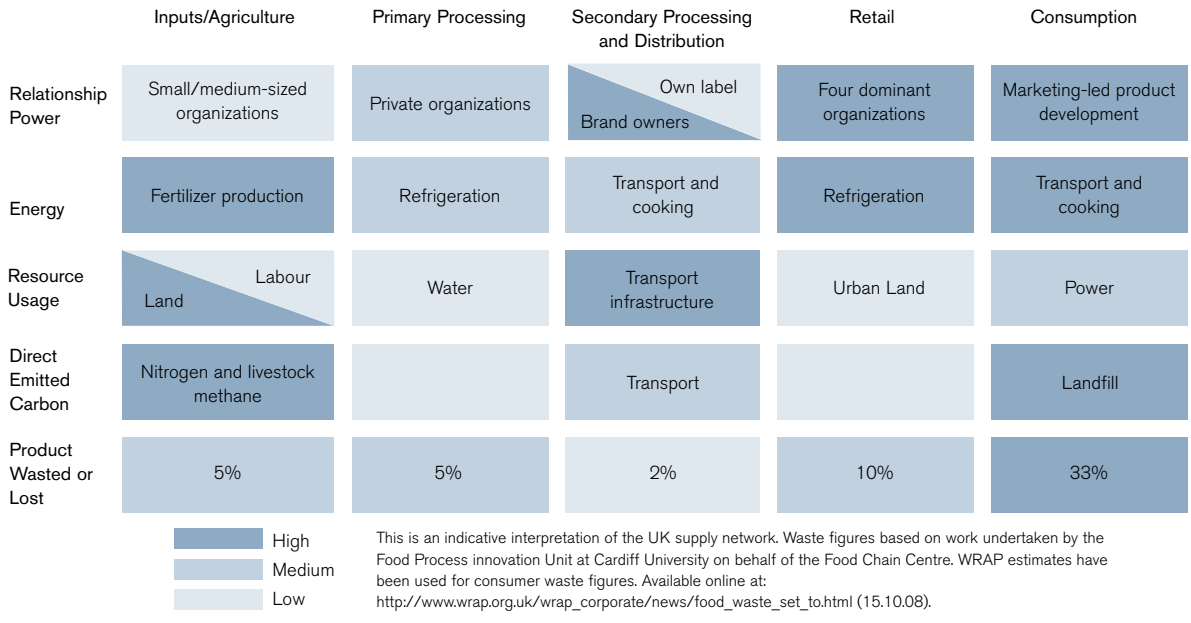
The food services sector – comprising diverse outlets from restaurants and pubs to the non-residential provision of catering in public institutions – now accounts for up to half of UK consumer expenditure on food (£79bn in 2007[c]). With more reliance on commodity products, its supply chains have tended to be less sophisticated, though the larger-scale organizations are now adopting systems similar in style and operation to the retail sector's.

The food manufacturing sector works to rigid, retailer-led product and service specifications, with the emphases placed on food safety and delivery flexibility. The sector has seen a progressive erosion of the domination of branded product suppliers, to the point where retailer 'own label' suppliers now have significant market share. Consolidation is a key trend in this sector and economies of scale have driven migration towards centralized manufacturing plants.

The UK farming sector is highly fragmented, with over 300,000 registered holdings.[d] A wide variety of business models is employed, but predominantly based on farmer ownership of land (69%); this has remained fairly static since 1990.[e] Some 63% are judged to be below the minimum threshold for good margins and farm-gate prices remain a contentious issue. Since reform of the EU's Common Agricultural Policy (CAP), subsidy payments still provide a major source of income, although the basis of payment has switched away from incentivizing volume to a land-based subsidy linked to compliance with environmental standards. Their relative lack of bargaining power in the supply network has led producers to develop more direct means of sales (e.g. farmers' markets). Livestock and arable products are predominantly channelled through a trading system, often managed by third parties; relationships here are often of a short-term, transactional nature. The dairy and horticulture sectors have seen a rise in more integrated chains with direct, contractual relationships with manufacturers and more recently retailers. Here, producers are incentivized through pricing schemes to meet tighter quality and other product specifications, directly linked to retailer requirements.

Figure 11 provides a view of the dynamic operating in the UK food supply chain and its resource footprint (excluding imports). Food production draws on a high proportion of UK resources in the form of land for agriculture, water and use of road infrastructure to transport food. It will be seen that energy usage and directly emitted carbon are concentrated in two sectors of the supply chain. The first is agriculture, through both the production/application of fertilizer and methane emissions from livestock; the second is retail, with its reliance on store/depot refrigeration, home transportation, home refrigeration and home preparation. The intermediate stages of the supply chain are more industrialized and use/emit comparatively less energy and carbon. On average, over 50% of the volume channelled through the system is wasted, a significant portion of this within the home.

Figure 11: The UK food supply system



This is an indicative interpretation of the UK supply network. Waste figures based on work undertaken by the Food Process innovation Unit at Cardiff University on behalf of the Food Chain Centre. WRAP estimates have been used for consumer waste figures. Available online at: http://www.wrap.org.uk/wrap_corporate/news/food_waste_set_to.html (15.10.08).

a TNS Worldpanel data (2007), Great Britain Consumer Spend: 12 Weeks to 07 September 2007. Available online at http://www.tnsglobal.com/_assets/files/TNS_Market_Research_Supermarket_Share-data-commentary.pdf.
b IGD (2007), Retail Logistics 2007. December 2006 (IGD, Watford).
c Defra (2007), *Agriculture in the United Kingdom*.
d Ibid.
e EUROSTAT (2008), http://ec.europa.eu/eurostat (last accessed 24 June 2008).

insufficient investment. As a result, food will become an embedded component of a new 'bio-economy' that will see government increasingly managing economic success around available resources. In these circumstances, sustainability as a concept must address a complex set of both global and more local-scale issues. There is much to be done if the required – generational – change in thinking and practice is to be achieved.

Sustainability is normally defined in terms of three pillars – economic prosperity, social development and environmental protection – but its meaning differs widely across society and industry, with a tendency for policy and business strategy to focus on narrower and more superficial applications. Although the UK government has articulated a set of sustainable development principles,[111] various studies have identified an apparent lack of vision in mapping out the detail of what a sustainable food system would look like.[112] Policy responses and measures already in place are tied to a series of as yet only loosely connected issues (bio-diversity, carbon emissions). In the continuing absence of a credible roadmap, there is a risk that the current policy framework for delivering environmental benefits will be too narrowly focused. The recent history of biofuels is an uncomfortable example of this. In the case of food specifically, the social aspects of sustainability are far from fully developed. The social impact of the food system goes much wider than just health, providing as it does employment and income for local communities (a factor of particular importance for rural communities, especially those in Wales and Scotland).

A crucial component of a sustainable food system will be its reliance on small-footprint technology; an emissions reduction of the order of at least 75% will be needed in the longer term to balance the (estimated) combined growth in the UK's population and affluence.[113] This would require a step change in innovation, one akin to the 'double Green revolution,'[114] plus improvements in efficiency, quality and waste reduction – in effect a new agricultural paradigm. The principle of eco-efficiency will be an essential element in the development of new food supply models. This form of efficiency is focused on reducing the environmental footprint of production: instead of production at lowest levels of cost, eco-efficiency aims at production with least environmental cost. Eco-efficiency for energy includes technology for reduction in end-use energy consumption and the development of renewable energy sources. Eco-efficiency for materials includes reducing the amount of material required for product manufacture and the reuse of materials through recycling. Opportunities for eco-efficiency in agriculture include methane digesters for energy generation, controlled-release fertilizer formulas to reduce runoff, recycling of waste biomass as 'green fertilizer', and drip irrigation systems to reduce water use. There are also new 'biological farming' practices in prospect. Access to these types of technology will become a key determinant of capability, and only by investing more in R&D (in agriculture and other food supply areas) will the UK be able to capitalize on what could be highly significant global developments. New, differently targeted, programmes of R&D will be required to support the transition to a lower-input, more regenerative system. Expertise in areas such as nutrient cycling, energy balance optimization, system synergies and life-cycle costing will acquire a new importance.

The balance between lower-input systems and productivity will also become a key focus for consideration as work is undertaken to develop and adopt a new agricultural paradigm, a process that will take several years. The technology gap implied, together with tensions between different agricultural systems, promises a turbulent period of transformation. But if the issue remains unaddressed, it is likely that a more fragmented approach to UK farming will emerge, with only a proportion of farmers overall implementing a range of different eco-technical solutions. Here a central challenge, one that may directly influence the direction and timing of developmental studies, will be the incremental incorporation into the food supply system and its products of what are currently externalized costs – for example, those relating to carbon and other greenhouse gas emissions. For those who are quick off the mark, competitive advantage will follow.

The issue of sustainability is not confined to agriculture; it is a system-wide problem. In particular, there is an increased appreciation across supply networks of the need to tackle both greenhouse gas emissions and waste. Adverse economic conditions will continue to focus attention on the range of already existing or proposed

credible waste reduction initiatives. Emissions issues are more difficult. Until a clear economic value is assessed and attached to new lower-carbon systems, there will be few incentives for change. The system has a built-in inertia, partly as a result of capital already invested. It will also only move towards change as fast as the market allows; and food supply businesses will be reluctant to embrace new models unless and until they feel consumers are truly demanding that they do so. Further research will be needed to develop and evaluate food supply models that meet acceptable sustainable criteria, but the characteristics required are likely to include:

- linked national, regional and local perspectives;
- a significantly reduced resource footprint, specifically a reduction in reliance on agriculture's oil-based inputs;
- a synergy of contributing systems that will generate minimum levels of energy and other resource requirements;
- a regenerative rather than (net) extractive approach in the areas of production and distribution – particular issues will arise around the creation of better coordinated and optimized land use and the recycling of available raw materials;
- the concept of zero net waste across the whole system;
- the development of the network structures and systems that will manage the new flows;
- the management of consumer choice to fit new consumer–producer relationships;

The provision of the information needed to inform choices around the supply network will be of critical importance but this issue in itself is rife with complexities. How can consistent measurement schemes for environmental and social impacts be established? How can the need to maintain cost competitiveness be balanced against the potential burden of increased product traceability? How should products' performance be weighted relative to environmental, health or other welfare-based criteria? How can information be presented to supply chain partners and consumers alike in a coherent and practical way?

The broader application of higher EU standards of sustainability will need to be carefully balanced. Unless similar requirements are imposed on imports from non-EU sources, there is a risk that, in effect, unsustainable practices will be exported rather than dealt with. On the other hand, compliance difficulties could lead to a contraction in trade that would conflict with the goal of supporting agriculture in developing countries. Unilateral imposition of higher standards for traded products could be perceived globally as a new form of EU protectionism and any such measures would need careful handling at a World Trade Organization level.

Resilience

Resilience may be conventionally defined as the ability of supply systems to provide an uninterrupted supply of quality food in sufficient volume and range to meet the needs of the UK consumer. Risks to resilience are usually conceived in terms of sudden disruptive shocks followed by an all too familiar (if invariably painful) process of recovery to competitiveness. But concerns about sustainability are now generating an additional ecological dimension that focuses on the food system's basic ability to continue to function.[115] This shift from maintaining *efficiency* of function (engineering resilience) to maintaining *existence* of function (ecological resilience) will take time to be developed and incorporated. In the meantime, if the food system is to keep operating successfully, its ability to recognize and respond to broader uncertainties inherent in the new operating environment must improve significantly. Wider questions such as the availability of basic resources – land, water, energy and skills – as well as growing competition for raw materials will create an entirely different sense of what constitutes 'risk'.

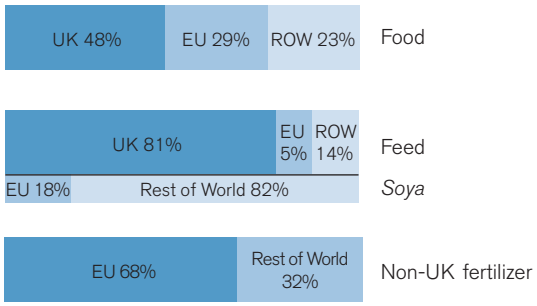
It will be increasingly important to understand the dependencies inherent in the UK's food supply system, particularly those with a global dimension. The current underlying balance between domestic, EU and global sources may at first sight appear to score well in terms of resilience. The EU is by far the largest source of UK food imports.[116] But there are key exceptions. The supply of fruit to the UK market is particularly reliant on global trade, the UK being only 10% self-sufficient in this sector.[117] UK food

production also continues to be critically dependent, particularly for key inputs such as animal feed (soya) and fertilizer (Figure 12), on a small number of sources in the wider global market-place. In a world where trade of food and resources may become subject to more political control, these will need to be kept under critical review.

Increasing strategic control of food is already in evidence. Recent market responses in nearly 40 countries around the world, delivered principally through the imposition of export controls,[118] provide a sharp reminder that reliance on a fully functioning global trade system comes with a degree of risk. Recent UK government policy advocates the promotion of global food security as the means to guarantee domestic food security.[119] Raising agricultural productivity in developing countries and reducing trade distortions will help to improve *global* food security;[120] but, in an environment where bilateral relationships designed to secure national food supplies are increasing, there is no guarantee that an expanded global pot would secure supplies for the UK. Indicators suggest that major Asian and Middle Eastern countries are already bypassing the world trade system altogether, pursuing bilateral deals (including the leasing of land) to secure essential supplies such as oil, minerals and agricultural products to support economic growth and food security.[121] While there is little evidence yet to suggest that this is affecting global availability of products, there is some unease within the UK industry about these developments. And while more research is needed, an argument may be made for the UK (and the EU) to take a more pragmatic approach in ensuring commercial access to non-EU-sourced supplies and products (potentially through the use of bilateral deals and more measures to encourage a more productive and competitive domestic agricultural base).

Some UK sectors may be more vulnerable than others. A crisis event (such as animal disease or extreme weather such as flooding) or even continued inflationary pressures on inputs would have disproportionate effects on livestock sectors. Key agricultural skills or assets – prime agricultural land, animal herds – would take many years to recover. The interdependencies between the sectors may also have consequences for resilience within the system as a whole. Such considerations raise the hugely significant questions of whether a minimum production capacity may need to be established within the UK, or whether critical thresholds are required below which sectors, such as dairy, should not be allowed to decline. This does not imply a return to protectionism, nor is it a plea for self-sufficiency; rather it reflects a need to extend to food supply the global awareness of risk and uncertainty that is already embedded in the security, defence and other sectors.

Figure 12: Sources of UK food, feed and fertilizer



Sources: Food: Defra (27 March 08) Agriculture in the United Kingdom, Chart 7.5, https://statistics.defra.gov.uk/esg/publications/auk/2007/excel.asp (data are 2006, based on the farm-gate value of unprocessed food; processed foods are revalued to their unprocessed value).
Feed: Calculated using feed information from HGCA (2007) Market Data Centre, http://www.hgca.com/data/ and data from FAOSTAT (accessed 15 August 08), http://faostat.fao.org/ (data are an average 2000–05).
Fertilizer: UK HM Revenue and Customs UK Trade Info (accessed 17 September 2008), http://194.223.26.124/HMRC/TableViewer/tableView.aspx (data are 2007, based on volume). Includes all types of fertilizer (code 31).

Traditionally, resilience strategies focus on the building in of systems redundancy, either through excess capacity or through increased stocks. In the context of food supply, these must be treated with caution. It is true that more regionally based supply systems could be more robust, particularly in times of crisis. But they are also are likely to attract additional facility costs and create negative impacts on the environment through less efficient transport systems. The establishment of national or regional strategic stocks is also a recognized response to supply volatility and uncertainty. Proponents of free trade would argue that such measures contribute to price inflation in the short term and send a negative signal to the market that leads to lower supply and high prices in the longer term.

Although the building of resilience is an increasingly multi-faceted endeavour, basic contingency planning will remain a cornerstone of the management of risk and uncertainty. Organizations, both small and large, will need to have adequate arrangements in place for their own operations and an understanding of how they relate to others in the supporting supply network. But corporate planning is not enough; responses to developments must be engineered, tested and exercised at a system level, with inputs coordinated between all stakeholders, including government. There is a widespread perception that a more detailed governmental understanding of food supply networks is required, not least to ensure that any interventions do not exacerbate problems or create unintended consequences. Scenario-planning approaches, along with effective horizon scanning, are to be encouraged to ensure that wider uncertainties are considered.

Competitiveness

Higher oil prices, continuing global supply-demand constraints and the cost of implementing environmental regulations will maintain pressures on input costs and commodity prices. The delivery of affordable, if still more expensive, food will rest on the supply system's ability to dampen the worst effects. For example, although the level of sterling is a major factor in relative price competitiveness, it is likely that retailers will continue to focus on the most globally competitive solution. Inflationary effects and the need to cut costs could see some migration of secondary processing activities out of the UK towards areas with lower labour costs. That would particularly suit companies with a multinational presence. However, if the oil price recovers over the longer term (>$100 per barrel), the consequent hike in transport costs may force a more regional focus on the supply of bulk commodities,[122] though any such moves will need to be judged also in resilience and sustainability terms. Continuing price pressures are also likely to reinforce the intensive farming model globally and across the EU agricultural base. Further increases in intensification are possible, signalling increased tensions between different agricultural approaches.

The 'old' definition of competitiveness, based solely on economic criteria, is already under strain. The search is on for a 'new' approach that builds longer-term ecological and social needs into financial and supply chain business models. Part of the challenge will be the incremental incorporation into the food supply system and its products of what are currently externalized costs – for example, those relating to CO_2 and other greenhouse gas emissions. In that regard, the definition of efficiency will need to be expanded to encompass effective resource access and utilization, an essential component of future competitive advantage. Associated policy and regulation will need to be developed in parallel to facilitate these changes (such as implementation of a standardized system for costing of carbon and other externalities).

The period of transition to a lower-carbon/lower-input system will present particular difficulties for the resilience and competitiveness of UK agriculture. Livestock sectors face specific problems in securing reductions in greenhouse gas emissions; arable and horticulture sectors face a potential drop in yields. Without some level of support, they will fail. There will also be a need to support technological development and the introduction of innovative agricultural practices. Questions remain about the levels of public- and private-sector agricultural R&D and how they can be increased in an environment of limited economic growth; agricultural investment is particularly dependent on confidence in the sector's prospects for stable returns. Innovation and the adoption of new practices will be essential, and the encouragement of new entrants will help to revitalize the sector. For this to happen, current UK policy incentives and regulations towards land ownership will need to be reviewed.

Governments will need to continue to work towards shaping a framework that allows access to the necessary capital for smaller producers and new entrants to invest in and develop sustainable, productive practices as well as incentivizing investment in other areas of the food chain. The forms of support needed are issues that should guide the UK's negotiation on the reform of the CAP post-2012.

Managing consumer expectations

In the UK, 'the problem' up to now has been over-consumption, not insecurity of supply. Consumers have grown to expect a plethora of choice and all-year-round availability of food, and expectations that prices will continue to fall as a percentage of discretionary spend are embedded in modern lifestyles. But the analysis and scenarios show how this expectation may well be challenged by events. The key political challenge will be the balance to be struck between individual consumer preference on food and the wider choices made by society on the systems that supply it.

> "The key political challenge will be the balance to be struck between individual consumer preference on food and the wider choices made by society on the systems that supply it"

The extent to which consumers are likely to drive the transformation of the current system is a key point of debate. Some of today's enlightened consumers are already demonstrating the core values that chime with ideals of sustainability, and almost 80% of consumers have had some engagement with ethical shopping.[123] Almost a third recognize climate change and packaging waste as issues of concern.[124] But reliance on a single consumer 'voice' to direct the market towards sustainable behaviour patterns seems misplaced; the customer requirement is likely instead to manifest itself as a set of fragmented and diverse responses.

Both industry and government need to acknowledge their responsibilities in helping consumers make informed choices. But the way ahead is not easy. An expansion of current labelling-based initiatives to address the resources impact of products will encounter complex and apparently competing criteria and it will be very difficult to communicate clearly to the consumer the net benefit of purchase in each case. Measures such as 'back-room' selection of more sustainable products on behalf of the consumer (choice editing) are considered to be a more fruitful route. An important early step will be for government, industry and civil society jointly to create an understanding of what constitutes a sustainable consumption pattern. The correct balance will need to be struck between industry and government 'push' (e.g. choice editing) and consumer 'pull' (demand for more sustainable products).

5. The New Dynamic

Work must start now to create a UK food supply that meets new standards of resilience, sustainability and competitiveness based on stakeholder partnerships

To deliver the new arrangements, the UK will need policies, systems, institutions and capabilities (knowledge, skills, technology, processes, structure and behaviours) that successfully reconcile resilience, sustainability and competitive advantage with consumer needs (the 'enablers/disablers' of Figure 10). The EU will continue to play an important role in supporting future UK food requirements. Future governance frameworks for a sustainable food system have to reside at an EU level, in case any major differences in approach create competition distortions across the free trade bloc. Future UK policy responses will need to carefully consider how best to maintain and develop the EU relationship to strike an appropriate balance between national and wider interests.

Technology will play a significant role in delivering the step change needed in global productivity, and for the UK transition to sustainable production. Success will depend on both the development of new technology, and the transfer and sharing of existing technologies and best practice.

The level of both private and publicly funded UK agricultural research has seen a reduction in real terms of around 40% between 2002 and 2006.[125] The declining levels of UK investment raise real questions over the country's ability to maintain a viable domestic agricultural R&D base, or to access technology developed in the EU or globally. A Defra study points to the UK as a follower rather than a leader in agricultural technology.[126] Demands on the government to set a clear agenda for general and more targeted research are likely to increase, along with calls for an urgent review of the level of public funding required, both to contribute to the global challenge but also to support innovation within UK-based food systems. Part of delivering the required change will be better support for research-based institutes and help in developing the private-public partnership frameworks needed to support technology transfer, particularly across the agricultural base.

As part of the coordinated technological response, the debate over GM technology will need to be reopened. GM crops are cited by many food supply professionals as among the tools required in efforts to reconcile the maintenance of agricultural productivity with more sustainable and affordable food production. The issue remains highly contentious in the UK/EU. Objections centre on a number of issues including health concerns, problems with loss of biodiversity, coexistence with other crops, and the patenting of crops that creates concerns about the degree of access for small farms.[127] In addition, traceability is likely to become a critical concern as GM crops that produce pharmaceuticals and industrial feed-stocks are more widely introduced. While national government has taken steps to reopen the debate,[128] the Welsh and Scottish governments have taken a strong line against GM products and are looking to preserve their GM-free commitments. Further debates among supporters within the producer base, between UK national and devolved governments and between the EU and other trading blocs over GM policy can be expected.

Many of the policies needed to harness scarce resources will involve consumer behaviour. In a resource-conscious world waste minimization will be vital to economic success; but where waste arises, options beyond disposal, which generate secondary resource, will be vital. Policies to determine effective land utilization and to conserve water and energy are dependent on wide-ranging public participation and support (e.g. the location of waste processing and recycling plants). Consumer buy-in is particularly vital in relation to the deployment of technologies, not merely genetic modification of plants but also those involved in related sectors such as energy and packaging. The technologies needed to deliver a new model of food production may be many and varied and may cut across current entrenched positions. Better engagement with the public over the framing of questions

Table 1: New and emerging supply chain requirements

	Old models	Emerging models
Farming system	• High input systems. • Established practices.	• Low input/high output optimized systems. • High levels of experimentation. • Waste reuse.
	• Subsidies without condition, price support.	• Subsidies dependent on sustainable production practices. • Support structures for investment, knowledge transfer and technology access (rather than direct support).
	• High levels of inefficiencies pre-2005. • Mid-term reform of CAP begins process of consolidation of farming businesses. Ownership and production start to separate.	• Competitiveness through horizontal collaborative models. • Increase in farm scale along with separation of ownership and production.
	• Focus on volume production pre-2005. Mid-term review begins process of aligning production to market requirement.	• Optimization of resources to align with sustainable goals. • Minimization of losses in whole system through horizontal production networks and vertical supply chain efficiency.
Supply processes	• Organizational risk management.	• System-based risk management. • Crisis management for whole chain.
	• Individual measures based on quality, cost and delivery performance.	• Shared measurement systems based on cost-competitiveness. Compliance with public requirements for resilience and sustainability.
	• Process efficiency.	• Resource efficiency.
	• Management of product flows.	• Integration and management of waste streams with product flows.
Products	• Wide product choice.	• Product rationalization and editing of choice, based on higher standards. • Use of substitutes and alternative ingredients.
Assets and structures	• Large, capital-intensive assets.	• More flexible use of assets. • Increased investment in smaller-scale assets. • New assets related to waste reuse lead to more horizontal collaboration, particularly in producer networks.
	• Investment decisions based on production cost per unit.	• Investment decisions based on total cost of ownership (inc. environmental costs).
	• Efficient distribution systems.	• National models developed alongside regional sourcing overlaid on efficient distribution models. Inefficient local models replaced by local solutions integrated with existing efficient distribution models.
Relationships	• Vertical transactional relationships. Limited horizontal collaboration.	• Greater horizontal collaborative relationships. • Longer-term supply contracts where power is in equilibrium.
	• Linear relationships. • Sector-based engagement.	• Partnerships with other sectors/industries. • Interlinkage of whole chain, from farm through to consumer. • Engagement with all stakeholders.
Strategies	• Price vs product differentiation.	• Additional competition based on low environmental impacts due to high public incentives and costs of non-sustainable supply.

of the application of such technologies will be vital to avoid impasse at a time when swift response may be required.

Supply chain arrangements will need to be restructured. This will require the formation of new, competitive business models that reflect the higher cost base. Investment decisions and strategy formulation will need to expand from the current narrow model of cost, quality and delivery to deliver a wider set of criteria – carbon reduction, resource utilization, social and environmental impacts, supply chain capability, etc. Product ranges will need to be balanced against these wider considerations, and this will probably lead to considerably less consumer choice. Less choice, but with ranges which offer higher product standards, would also help to deliver significant health and environmental benefits. The choices made will be delivered through retail and branded product specifications that will have to be adapted significantly; and mechanisms will have to be found for a 'framework of integrity' to operate across the supply chain as a whole to monitor compliance. Some indicators of how current characteristics of the system may need to change are presented in Table 1.

Constraints on resources and increased difficulties in sourcing raw materials and other inputs point to a move away from simple transactional relationships to longer-term contracts and substantive relationships with suppliers. Supply shortage will tend to shift some power back to producers. Other pressures such as assuring product standards through the chain and the need for coordinated crisis management also indicate a turning point in supply relationships. These factors will drive a need for increased information-sharing across the chain and greater transparency of standards. Chains currently disconnected from consumers will need to create a more integrated approach. Retailers and the major food service providers will remain key, both in driving forward the new models and standards and in fostering better relationships. With or without government regulation and/or changes in shareholder expectations, retailers in particular will need to adapt their practices to alter the balance of risk and reward throughout the chain.

There are likely to be conflicting visions of the new system, and tensions between potentially competing goals will define the UK's food supply arrangements for the coming decade (Figure 13). A fault line exists between those advocating radical restructuring and those who believe the solutions lie in the adaptation of current arrangements. Future strategies and policy must be based

Figure 13: Transition from old to new goals

on consideration of all the elements as a whole, with inevitable trade-offs that will include addressing the following questions:

- How far can standards of health, safety, welfare and ethics be maintained in sustainable food supply?
- How can a competitive system be maintained that provides affordable food while remaining socially and environmentally sustainable?
- How can a resilient system be developed within the context of geo-political uncertainties?
- How should policy be shaped in order to encourage more sustainable behaviours but without inhibiting UK cost-competiveness?
- What should be the balance between the market and the state in the future system?

National government is responding, with the outcome of one major review of food policy already published[129] and other policy work in the pipeline. The Welsh and Scottish governments also launched significant consultation documents on food strategy and policy in 2008.[130] Governmental thinking overall appears to be framed around the following guiding principles:

- keeping food prices for consumers low;
- encouraging access to open, competitive markets;
- maintaining food safety;
- ensuring environmental sustainability;
- delivering healthier diets;
- keeping the state's fiscal burden as low as possible.

The increasing political profile of food, and impending CAP reform, will force national and devolved governments to consider their leadership roles in taking the debate forward. Part of this is the recognition of the role they will have to play in ensuring the *competitiveness* and *resilience* of the food supply system in the face of attempts to narrow free trade under global resource constraints. There would seem to be little tension between UK self-interest and the wider need to ensure that trade in food is free and fair. Government also has a role in ensuring *sustainability* in the food supply chain and in leading and shaping *consumer expectations*. The moral and ethical dimensions of trade may also become more important for UK consumers. Along with objectives of supporting the economies of developing countries, the resource footprint associated with imports will need to be factored in to trade policy and individual procurement decisions.

Ultimately, UK governments will be expected to develop, in line with the EU, the overarching policies and regulatory framework plus any necessary market reframing that will be needed to meet the wider challenges. Their current thinking[131] needs to be broadened and developed into a clear vision of the UK's future food system. A vital first step will be for governments to gain an understanding, sector by sector, of the operation and complexities of current food supply arrangements.

The commercial sector remains best placed to deliver the operational capability required to meet the new goals. But it is unclear whether it can easily reconcile today's commercial imperatives – locked as they are into current business models – with the wider public interest. In particular, the development of new food supply models will require a different mind-set. A vital component of the process will be the incorporation of true supply costs, many of which are currently externalized – carbon and water being the obvious and major examples. Ingrained short-termism will need to evolve into a more strategic focus. That may be illustrated on one level as the difference between industry's current 'fire-fighting' obsession with immediate public issues – quality of ingredients, obesity etc. – and a corporate responsibility profile that reflects a longer-term understanding and management of the resource footprint.

As it evolves, the system still has to be capable of delivering sufficient quantities of food for the UK population. Domestic production will continue to play a significant role in the UK food's supply. Indeed, as resources come under pressure, and in a low-carbon economy, food grown and consumed locally will provide much more significant benefits to the national economy. The capacity to respond will depend on addressing the increasingly acute skills and labour shortages. Economies of scale will continue to play an important role in both productivity and profitability, particularly at a farming level. However, the role of more

regionally based systems and assets in providing a greater degree of resilience will need to be considered. Any benefit must be offset against potentially significant environmental and cost trade-offs. Scale will also be a key component of profitability at farm level, with land prices likely to continue acting as a barrier to expansion. The further development of different ownership models (such as contract farming) may be worth exploring.

Any temptation to focus on the UK agricultural sector in isolation must be resisted; part of the solution lies in developing the capability of the food supply system as a whole. There will be an extended transition period in which a patchwork of the old and the new will be evident. In that ferment of experiments, many of them small-scale and 'below the radar', there are unlikely to be many absolutely right answers. A set of related initiatives is likely to be required, which go further than current UK/EU policies and are built around new frameworks for technological innovation, waste reduction, partnership-led approaches and acceptance of possible changes in consumption patterns.

That in turn means that policy must avoid blanket prescriptions and allow instead flexibility within a suitable framework of parameters. While government may need to step in to discourage bad practice and develop more disciplined frameworks (e.g. the Climate Change Bill), such actions must be still be capable of responding to the rapid roll-out of new technologies, processes and/or changes in external circumstances (e.g. those explored in the scenarios). The need for increased investment in scientific and technological research and development, and how such efforts should be funded, will come to the fore.

The issues raised cut across multiple areas of policy and operational expertise. Reconciling the often conflicting elements and combining them into coherent food supply models for the different sectors will become the central challenge of the next decade.

Food supply is becoming a major political issue. The seven fundamental influences operating in the global food system are combining to generate circumstances that are new in modern experience. Protecting British interests is a necessity; advancing them by exploiting efficiently the new opportunities on offer is a real and exciting prospect. Developing a new national strategy and prioritizing the sustainability and productivity of domestic food supply and demand should complement the UK's EU and global obligations. Alternative food arrangements must be structured first and foremost around the effective utilization of resources to become lower-input systems. This is at the heart of 'the new normality'. It will require a staged process of transformation, and the work already started by the Cabinet Office and Defra is to be warmly welcomed as a first step.

6. Conclusions and Recommendations

Policy and political outcomes

UK food supply is already highly dependent on trade within the EU and is likely to remain so. It follows that much of the work on shaping a new food dynamic must lie within Europe. Such policies cannot be as narrowly drawn as in the past and will necessarily involve wider questions of strategic, environmental, social and cultural considerations. Continuing debate over CAP reform offers an opportunity to redraw the boundaries of European food policy, and the UK has already shown active interest in carrying this debate forward.

Within this context, in re-conceiving its own food supply arrangements, the UK must develop a clear vision of where its national interests lie and how best they can be met. In particular the vision should articulate how food supply supports best outcomes in a range of policy areas (for example, consumer health, security of supply, the domestic economy, environmental objectives, regional prosperity, social equity, food culture). It should also include a statement of the UK's strategic and geo-political interests as they relate to resilient food supply, and a set of principles and accompanying indicators/metrics that will characterize a food supply business model capable of reconciling resilience, competitiveness and evolving consumer expectations. Its implementation will have implications for a range of domestic policies. Health, social, rural energy and environmental domestic policies are all at issue here, as are outward-looking strategies for foreign relations, trade and international development. Workshops held in the course of the research in Edinburgh and Cardiff encouraged the view that devolved government provides the opportunity for testing the capacity of localized response to the global pressures and for the development of regionalized systems within a single European market.

The development of a more strategic approach to the UK's food supply will require a programme of coordinated work which must reflect fully the different perspectives of devolved and central governments. Its ultimate outcome will be UK food supply arrangements that reconcile commercial imperatives with global realities and changing domestic policy objectives. The new approach is likely to be one that:

- with consumer acceptance, will operate profitably with higher prices as a norm;
- will reconcile resilience, sustainability and competitiveness.

The work should be driven by a consortium juxtaposing the expertise of governments, supply network interests and a range of societal groups (media, NGOs, universities), and will need to be managed through a multi-stage plan, the outcomes of which will influence the UK's negotiations on the shape of the CAP post-2012. The key outputs are shown in Table 2, which outlines suggestions for the initial stages of work and longer-term areas of study.

This work now needs to be accelerated to develop a universal policy framework with clearer criteria and a new set of indicators and metrics. Detailed sector-by-sector roadmaps will also be essential. The supporting process must be based on a systematized partnership between stakeholders across the sectors, operating on the basis of transparency and trust. As issues such as energy security, food security and political security become inexorably intertwined, the stakes are raised, as is the price of failure.

Table 2: Recommendations

Timescales	Lines of enquiry	Outcomes
Initial actions	• Agreement on the status and scope of the consortium to deliver the vision.	• Establishment of a cross-sector consortium.
Short term	• A map of the resources, sources and dependencies underpinning the UK food system with a focus on identifying potential vulnerabilities. • An examination of the critical mass of UK food production sectors, the minimum level at which they could function and the implications of the loss of certain elements. • The development of measures to encourage increased investment in agriculture to encourage both highly productive and sustainable practices.	• A vision statement to guide the development of the UK's future food supply. • A plan for creating and maintaining the necessary UK skills base. • A declaration of priorities in domestic land use.
Medium term	• The nature of consumer demand and its capacity to adjust to social and cultural expectations in the light of market realities and policy priorities. • The national, devolved, regional, local dimensions of food and its role as a determinant of identity. • The desired consumer outcomes including the nature of a sustainable diet. • The role of regulation, 'consumer choice editing' and marketing in shaping consumer choice.	• A description of the EU/UK's 'sustainable consumer diet'. • The development of communication and education strategies to engage the public on key food issues.
	• Research into the best application of investment in R&D to ensure acceptable food supply and (more ambitiously) food supply that will deliver new competitive strengths. • The development of a framework of institutions and public-private partnerships to facilitate R&D development and dissemination.	• A plan for increased and selectively targeted public investment in UK food supply R&D. • A strategy for knowledge transfer and technological access for the UK's agricultural base. • A strategy to engage the public in the framing of scientific development within agriculture and food supply.
	• The role of industry in the new supply environment – regrouping, restructuring around new functions that include issues such as waste management and product simplification. • Strategies for waste reduction and a consideration of the best environmental options for food waste. • The development of new competition models with a regenerative rather than extractive emphasis. • The best options for targeted investment in infrastructure.	• The development of standards that extend beyond price, quality and turnover, to shape a sustainable food supply system. • A set of proposals for the specific changes required in policies, structures, systems and practices across the UK sectors. • A programme to ensure that waste-related considerations are reflected in new policy and regulatory structures.

Notes

Chapter 2: The Global Context

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Chapter 3: The Implications for the UK/EU

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Annex A: 'UK Food Supply in the 21st Century: The New Dynamic': Research Scope and Methodology

Research scope

UK food supply chains now rest on complex networks that span countries and continents. Serving a critical area of the British public good, their exposure to global trends and influences is nevertheless increasing all the time with changes already observable from:

- the impact on global markets of new levels of demand, particularly from the major emerging economies;
- the effects of climate warming on regions of production and the implications for trade and international relations;
- inflationary pressures on food pricing;
- the competing demands of food, fuel and feed on land in the UK and elsewhere;
- the need to conserve energy and reduce damaging emissions.

This project has been a two-year programme of research designed to evaluate the effects on the UK's food supply of changes in the global dynamic. Focused on the UK's wheat and dairy supply systems, the study's aim has been to deliver an assessment of the UK's capacity to respond to the new challenges. Crucially, it has explored the strategic options open to each echelon of the wheat and dairy supply systems as well as the adjustments required in (EU/UK) government policies and the governance framework under which the new supply arrangements will be required to operate.

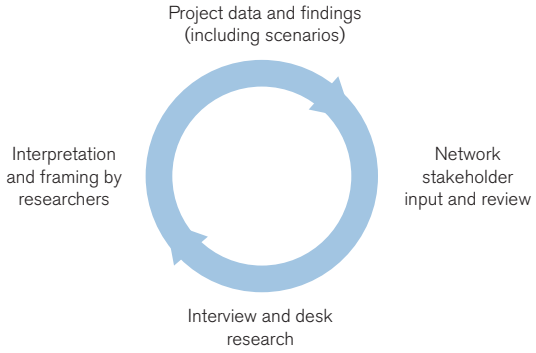
The project has not been concerned with crisis-led contingency planning. Rather, looking beyond the planning cycles of most cross-sector organizations, its effort has been directed to understanding the next generation's experience of food demand and supply – the 'new normality'. Specific deliverables include:

- a new methodology for evaluating demand and supply arrangements;
- models of the UK's future wheat and milk supply networks;
- outlines of the new practices required in domestic and overseas (wheat and milk) production;
- maps of the key stakeholder relationships, existing and future models of alternative governance arrangements.

Research methodology

The overall methodology used in this study combines as its key principles research, participation – and iteration between the two (Figure A1). A sustained objective has been to ensure engagement of the widest range of supply network opinion at each stage.

Figure A1: Project process iteration



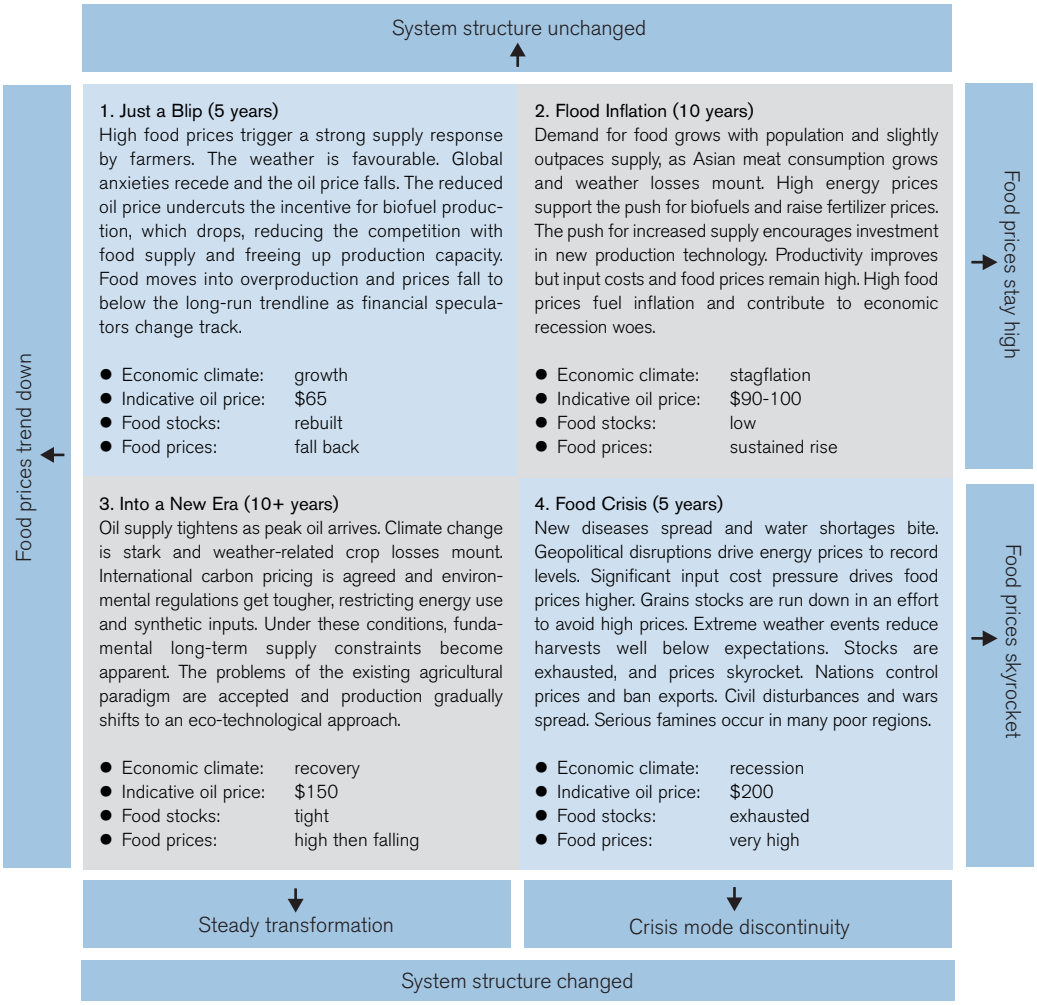
Scenario development

An important aspect of the project has been the development and use of scenarios to identify significant indicators of the future that are already observable in the present environment of global demand and supply. Employed as illustrative rather than predictive tools, the scenarios have been used both to generate debate and to analyse the outcomes of exchanges. As explained earlier, they have been one part of an iterative process that has seen data and analysis continuously circulating between researchers and stakeholders from across the supply networks.

The essence of scenario thinking is to anticipate the spread of future possibilities to help policy-makers and decision-takers make more informed strategic choices. To put this in another way, it is more valuable to think through a range of possible outcomes than to pin everything on a single prediction of what will happen in the future. Scenario thinking involves asking what could happen and, having understood that, asking what we might start doing differently *now* in order to create new policy and strategy options.

Scenario development often involves the use of forecasting techniques to quantify the future value of important variables under different assumptions, but it is important not to treat these forecast values as single-point predictions of the whole outcome – a move which typically leads to shallow and misleading strategic reasoning.

Figure A2: The four scenarios



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The project's scenario development process began with 45 research interviews conducted with food supply industry participants and stakeholders throughout 2007. They were used to collect participants' perceptions of key food supply issues and future prospects for the UK's wheat and dairy industries. The results were taken as the starting point for constructing a set of descriptions of the 'future situation'. The range of ideas and concerns expressed by interviewees was then complemented by desk research to explore and deepen understanding of the various issues raised. From the combined findings, key drivers were identified as shaping the present and emerging situation. The interactions between those drivers were then explored using systems-thinking principles, and a variety of potential global situations emerged. Story-lines were constructed around these 'future potentials', turning them into a set of four global scenarios of food supply.

The scenarios were presented in a series of workshops with food supply network players and stakeholders in various parts of the UK. Workshop participants provided feedback about the plausibility and systemic reasoning of the scenarios, which were modified to reflect better the information provided. Workshop participants then used the scenarios to anticipate the UK situation in each scenario and to identify appropriate actions by various parts of the UK food supply network. The workshop findings were extended by further research into the dynamics of the UK situation in order to draw a clearer picture of the implications for government and industry. The implications are presented in this report as observations and insights that we hope will contribute to the process of policy and strategy formulation.

Scenario 1: Just a Blip

High food prices prove to be a temporary blip and soon return to the long-term trend-line. There is a possibility, however, that if food prices fall back sharply, financial speculation in commodities will operate in reverse and lead to exaggerated food price volatility.

High food prices trigger a major investment in increased production. Over a two- to three-year period, marginal land and spare capacity are brought back into production, double-cropping is more widely adopted and food production surges. In spite of climate change fears, the weather proves remarkably favourable. There are almost no major crop losses affecting feed or food and sustained rainfall in Australia breaks the long-running drought, bringing harvests back to normal levels. Geopolitical stability in oil-producing regions is seen as improving following the 2008 US election, and oil supply concerns ease. As a result of receding global fears and a jump in energy efficiency investment, the oil price returns to levels around $65 per barrel or below. Food input costs decline. The reduced oil price undercuts the economic competitiveness of crop-based biofuels, and ethical pressure from NGOs builds. Biofuel production falls, freeing up food production capacity. The combination of a strong supply response and favourable conditions moves food into overproduction and prices fall. Financial speculation, which had been a significant factor in driving up prices, then shifts sharply, causing the food price to plunge further, ending up well below the previous long-run trend-line. Farmers reel from the dramatic collapse of food prices. This paves the way for volatility around the trend-line in the years that follow.

Scenario 2: Food Inflation

Food prices stay high for a protracted period. They contribute significantly to inflation, but the economy adapts and the existing food system copes.

Demand for food continues to grow in step with increases in world population. Higher meat consumption in Asia and further bad weather and climate-related crop losses ensure that demand persistently outpaces production growth, albeit by a narrow margin. Oil prices stabilize at around $90–100 per barrel, high enough to maintain the push for biofuels, and high gas prices and capacity constraints keep fertilizer costs high. The imperative to increase food production leads to widespread deployment of new technologies; these include a range of bio-technologies, and methods for improving the efficiency of water consumption and nitrogen application. Continuing efforts are made to reduce food waste in the system. Improvements in practices push up production but come at a price, with input costs rising overall. Production struggles to keep pace with demand and global grain

stocks are not rebuilt. Following the investments in new food production technology, the widely feared fundamental limit to global food production is avoided or at least delayed. The structure of the global food production system remains largely unchanged, but the new intensification adds to environmental pressures. In Europe, even as the supply of non-GM crops shrinks worldwide, consumers continue to resist imports of GM food and feed. EU policy requires reduced use of fertilizers and pesticides for environmental reasons, further adding to feed price pressure by constraining local output. Persistently high food prices contribute to the woes of a recession that hits developed countries along with high energy prices. High food prices add to pressure for wage increases in emerging markets, where expenditure on food represents a relatively large percentage of average income; this translates into higher export prices and contributes to inflation in developed markets. The world is ultimately judged to be experiencing a 15-year 'long-wave' upswing in commodity prices. The sustained high food prices, combined with the difficult economic conditions, cause a rise in the proportion of personal income spent on food, ending the previous long-run downward trend.

Scenario 3: Into a New Era

Input prices initially stay high as per capita production falls steadily. In response, the system of food production is required to shift dramatically so that increased yields are delivered efficiently through 'regenerative' rather than purely 'extractive' uses of resources.

Global oil production stays flat and begins to tighten. The view spreads that 'peak oil' has arrived. The oil price rises above $150 per barrel but is held in check by reductions in energy consumption and the widespread deployment of energy efficiency technologies. Oil prices sustained at a high level support a continuing emphasis on biofuel production. The effects of climate change become starkly obvious, with weather-related losses reaching higher levels every year. Developed countries agree on carbon pricing, and developing countries sign up over time. Many countries introduce water pricing in response to serious drought conditions. Tougher environmental limits on pesticides and fertilizers are introduced, and nitrogen pricing is debated. Food production per person is in decline, food shortages are more frequent and prices are climbing. Under these conditions, it becomes clear that food production is hitting fundamental long-term constraints. The media refer to this as 'peak food.' Social values and preferences shift decisively towards what are broadly viewed as 'sustainable' methods, and wherever there are affluent consumers, the demand for local, seasonal, increasingly vegetarian, fairly traded and organic food continues to rise. At the same time, high food prices permit investment in new agricultural technologies aimed at increasing production while addressing environmental issues – soil degradation, water contamination, pest resistance, biodiversity loss and greenhouse gas emissions. Over a period of 10 years and beyond, a new eco-technological production approach emerges that includes: crop rotation, cover cropping, agro-forestry, 'green' fertilizers derived from agricultural and food waste, new varieties (that have resilient, pest-resistant, nitrogen-fixing qualities), more efficient use of inputs through advanced information technology, and reduced water use. The new approach has a smaller environmental footprint, fewer synthetic inputs, better health outcomes, and higher yields. It starts in pockets, co-existing with the old approach, and gradually takes hold as more farmers adopt the new methods. The old approach gives way and the international food industry and trading rules gradually restructure around the new production paradigm, lifting the environmental and production constraints of the old system. Per capita food production rises as the new approach spreads and food prices finally begin to fall.

Scenario 4: Food in Crisis

Multiple shocks disrupt food production and supply. Prices skyrocket as stocks plummet, triggering food shortages, famine and civil panic.

Two serious global disturbances hit agriculture in short order: the rapid spread of crop/animal disease, and sharply worsening water shortages. These come on top of new geopolitical disruptions that affect energy supply. There are also continuing problems in financial markets. The oil price surges to record levels, well above $200. The increase puts significant pressure on food input costs, and food

prices are driven even higher by financial speculation. Very high gas prices discourage inorganic fertilizer use, further tightening the food and feed supply situation. Grain stocks are run down to new lows around the world in an effort to sidestep high prices, merely delaying the unavoidable impact of contracting supply. A succession of extreme weather events then reduces world harvests to well below the already lowered levels, and stocks are not rebuilt. Prices skyrocket as the true supply situation becomes apparent. Sudden and extreme food price rises prompt many more governments to introduce price controls, subsidies and export bans which further worsen the overall supply situation. Farmers are penalized by not being allowed to benefit from the high prices and food is taken off the world market. Other countries, particularly China, scramble to tie up bilateral food supply deals. In many parts of the world farming is seriously disrupted, further exacerbating the overall supply position. Serious food shortages develop which cause universal public shock and growing political panic. Severe famines, for which no food aid is available, occur in the poorest and least resilient regions. The shortages trigger serious civil disruptions and outbreaks of conflict. Directly and indirectly the food shortfalls cause millions of deaths, mostly in the developing world. There is turmoil in the food industry, with some firms making vast windfall profits and others going to the wall. New policies enacted on an emergency basis have their own unintended consequences. A completely untested set of supply arrangements is forged in crisis mode. The struggle, even in the developed world, is to keep people fed, disregarding where necessary any ideas of consumer choice.

Annex B: Research Team Biographies

With specialist scientific and technological, economic and additional consumer-related expertise co-opted as required, a core research team was assembled that represented excellence in each of the relevant fields:

Cardiff Business School

(Kate Bailey, David Simons, Alexandra Kiff): supply chain lean thinking/elimination of waste, supply chain design and sustainable development, performance measures, cross-supply chain collaboration, the use of information flows in business environments.

Kate Bailey is a Senior Research Associate within the Food Process Innovation Unit at Cardiff Business School. She has a background in supply chain and production management, having worked for major international companies within the electronics and automotive industries. She joined the Business School in 2004, and has since led a number of Value Chain Analysis (VCA) projects across the dairy, red meat, cereals and fresh produce sectors. She led the research team and coordinated the programme for the food supply project convened by Chatham House. She continues to work in the field of food supply, with particular focus on supply chain vulnerability, food supply networks and cross-chain collaboration.

After graduating as a Mechanical Engineer, **David Simons** completed an MSc in Management Science & Operational Research at Warwick University Business School and spent six years in Operations and Logistics consultancy. At Cardiff Business School, he has ten years' experience of supply chain analysis and implementation in the automotive and food sectors. With Dan Jones he facilitated lean thinking at Tesco from 1996 to 2002 and more recently has been principal investigator for a £3m research programme covering the four main agri-food sectors in the UK; red meat, cereals, dairy and horticulture. He is currently Co-Director of Cardiff Business School's Food Process Innovation Unit.

Alexandra Kiff graduated from the University of York in 2006 with a BA in Economics and Economic History. During her degree course her chosen areas of study included the globalization of production, the economic growth of developing nations, and the complexities of the international economy. Her current research interests include the impact of global changes on supply chains and future changes to UK food supply.

Centre for Business Relationships, Accountability, Sustainability and Society (BRASS, Cardiff University)

(Professor Terry Marsden, Professor Robert Lee): analysis of business relationships to promote sustainability, accountability and social responsibility. The interaction between businesses and their social and physical environment. Accountability across the food supply chain.

Professor Terry Marsden is the Head of Cardiff University's Department of City and Regional Planning and holds the Chair of Environmental Policy and Planning. He is the Co-Director of BRASS. Terry is a member of the Royal Town Planning Institute and co-editor of the *Journal of Environmental Policy and Planning*. His specialist areas of research include the agri-food debate and environmental policy.

Professor Robert Lee is a Co-Director of BRASS. An environmental lawyer, he is a widely acknowledged expert on contaminated land and waste management. He is currently working on a book on food regulation in Europe. He

continues to have an active interest in legal practice, being employed as a professional development consultant with the Environment, Planning and Regulation Group of Freshfields Bruckhaus Deringer.

City University

(Professor Tim Lang): food policy analysis, human and environmental health issues as they relate to social justice and culture.

Tim Lang is Professor of Food Policy at City University's Centre for Food Policy in London. His special interest is on tensions between state, supply chain and civil society policies, and how they shape (and respond to) competing demands about public health, environment, social justice and consumer rights. Most recently he and colleagues have completed a two-year EU 6th framework study of ethical traceability in the food chain.

In 2005-06, Tim chaired the Scottish NHS Executive's Scottish Diet Action Plan Review and, from 2005 to 2007, was an advisor to the Foresight Obesity programme. He is a Vice President of the Chartered Institute of Environmental Health and a Fellow of the Faculty of Public Health of the Royal College of Physicians.

Oxford University

Saïd Business School (Hardin Tibbs): scenario thinking to frame strategic concerns and global issues, the facilitation of debate, and analysis of the future effects of change and their strategic implications.

Hardin Tibbs is a management consultant with extensive international experience. He is an Associate Fellow at the Saïd Business School, Oxford University, where he co-teaches the executive education Scenarios Programme, and has a research role at the James Martin Institute for Science and Civilization, also at Oxford. An experienced scenario planner, he is CEO of Synthesys Strategic Consulting Ltd., and specializes in futures research and strategy development. He has been based at various times in the US, Australia and Europe, where his work has spanned a wide range of industries and issues, including food, bio-technology, natural resources, taxation and transport. In addition to his strategy work, Hardin has made significant contributions on issues involving technology and environment. He is also a Fellow of the RSA.

Chatham House

(Susan Ambler-Edwards, Project Leader): the link to expertise around the world on the analysis of international issues.

Susan Ambler-Edwards is a member of the Senior Civil Service whose career has been built on successive appointments in the central policy and operations staffs of the Ministry of Defence. Her areas of expertise include resilience of the civil infrastructure. Susan was seconded to Chatham House in January 2005 and led the food project from June of that year to December 2008. She holds an MA in International Studies from King's College, London.

CHATHAM HOUSE

Chatham House, 10 St James's Square, London SW1Y 4LE
T: +44 (0)20 7957 5700 E: contact@chathamhouse.org.uk
F: +44 (0)20 7957 5710 www.chathamhouse.org.uk
Charity Registration Number: 208223